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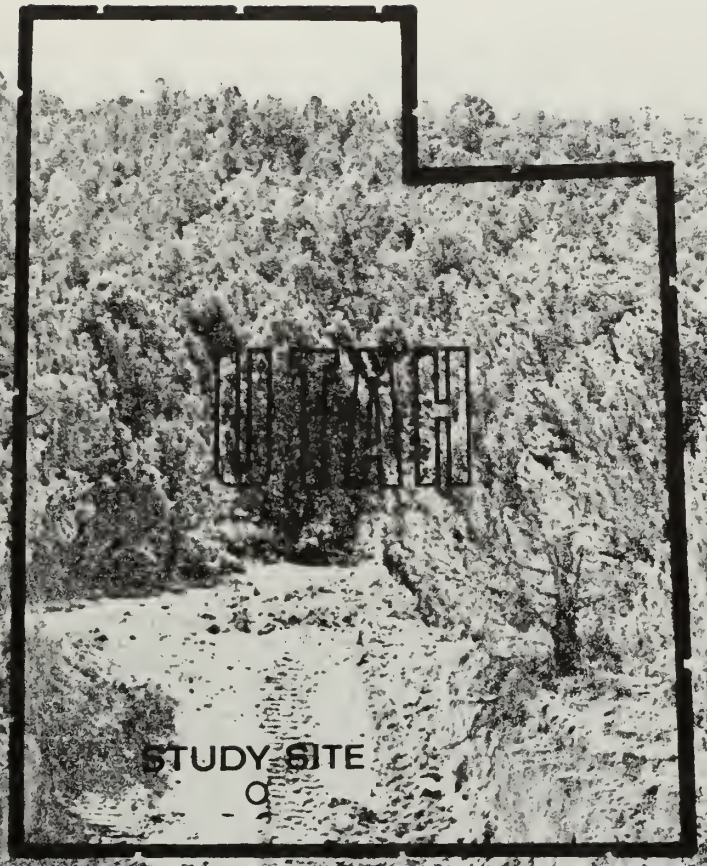

Resource and Potential Reclamation Evaluation

ALTON STUDY SITE

Alton Coal Field

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ENERGY MINERAL REHABILITATION

INVENTORY AND ANALYSIS

ALTON COAL FIELD

KANE COUNTY, UTAH

Cooperative Study by:
Bureau of Reclamation
Bureau of Land Management
Geological Survey

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EMRIA - Energy Mineral Rehabilitation Inventory and Analysis

EMRIA is a coordinated approach to field data collection, analysis, and interpretation of soil, water, overburden and energy resource data. The main objective of the effort is to assure adequate baseline data for choosing reclamation goals and establishment of lease stipulations through site-specific preplanning for surface mining and reclamation.

These reports are prepared through the efforts of the Department of the Interior principally by the Bureau of Land Management, Bureau of Reclamation and Geological Survey. Assistance is also provided by other Federal and State agencies.

Reports under this effort are:

EMRIA Report	Location	Source - BLM Offices
#1 - 1975	Otter Creek near Ashland, MT	Montana State Office Federal Building 316 N. 26th Street Billings, MT 59101
#2 - 1975	Hanna Basin near Hanna, WY	District Office 1300 Third Street P.O. Box 670 Rawlins, WY 82301
#3 - 1975	Taylor Creek near Craig, CO	Colorado State Office 1600 Broadway - Room 700 Denver, CO 80202
#4 - 1975	Alton near Kanab, UT	Utah State Office Federal Building 125 South State P.O. Box 11505 Salt Lake City, UT 84111

Interior - Reclamation, B.C., Nev. 11-75

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I. INTRODUCTION

I. INTRODUCTION

A growing and affluent society is creating an ever increasing need for energy. Attention has focused on the fossil fuels and sources existent in the western states, primarily the Rocky Mountains and Northern Great Plains coal provinces, due to the abundance, simplicity of extraction, and the high quality of the resources present.

It is the responsibility of the Bureau of Land Management (BLM) to assist in meeting these energy demands and at the same time provide sound reclamation and rehabilitation guidelines so that the lands subjected to disturbance are returned to a productive and useful state.

A. Purpose

The main purpose of this study is to assure adequate base-line data for choosing optimum reclamation and rehabilitation objectives and for establishing appropriate data and interpretations for preparation of lease stipulations through site-specific preplanning of mining and reclamation.

B. Objectives

1. To analyze and quantify environmental impacts from surface mining of energy minerals at the Alton Study Site in southwestern Utah.

2. To provide resource and impact information to the leasing site selection procedures as set forth by the Secretary.

3. To provide environmental resource information needed to implement effective reclamation and rehabilitation programs and for the development of meaningful lease stipulations as required by the Mined Land Reclamation Program.

4. To provide resource and impact information to support state and local regional development and land use planning efforts.

5. To determine the present and potential capability of the surface soil and subsurface resources to produce and maintain vegetation on known energy fuel deposits.

6. To provide physical and chemical data from which realistic stipulations may be prepared for energy mineral exploration, mining, and reclamation plans.

7. To provide data needed in the preparation of Environmental Impact Statements, Environmental Analysis Records, and to aid in the review of mining and reclamation plans for proposed land disturbing activities in the vicinity of the study.

C. Authority

The report was prepared under the authority of the Pubiic Land Administration Act of July 14, 1969 (74 Stat. 506).

D. Responsibility

1. Bureau of Land Management

a. Select reclamation study site areas for coordinated investigation of vegetation, soil, geological structure, surface water, and ground water.

b. Acts as Contracting Officer in the coordination, establishment, and execution of work orders.

c. Reviews and consolidates work order and field office data, and prepares input to reports published by the Bureau of Reclamation.

d. Procurement of easements and rights-of-way to conduct the studies.

e. Distributes technical data, reports, and reclamation and rehabilitation recommendations to BLM field offices.

2. Bureau of Reclamation

a. Conducts soil inventory.

b. Conducts drilling operations for the procurement of core samples to be used for the analysis of geological strata in overburden materials.

c. Installs casing in holes selected for ground-water observation wells.

d. Characterizes and interprets overburden materials as well as substrata immediately below the coal resources for reclamation.

e. Conducts greenhouse studies for determining overburden materials potential for supporting vegetative growth.

f. Conducts weathering tests of core samples to determine stability of overburden materials.

g. Advises and recommends suitable plant species for use in areas to be reclaimed.

h. Advises and recommends reclamation techniques.

i. Prepares a geologic map.

3. Geological Survey

a. Conducts vegetation and soil studies which will result in vegetation maps and related soil characteristics.

b. Assesses reclamation potential based on available water.

c. Prepares sediment yield maps.

d. Prepares erodibility maps.

e. Coal sections and well logs.

f. Coalbed maps showing coal resources.

g. Tabulation of coal resources estimates.

h. Table of analytical results on coal resources.

i. Graphic presentation of analytical results.

(1) Vertical - Plotted against well logs.

(2) Horizontal - Plan view if significant.

j. Prepares potentiometric maps.

k. Measures required to prevent adverse effects on surface and ground water of area.

l. Effects of mining on area hydrology.

II. GENERAL DESCRIPTION

II. GENERAL DESCRIPTION

A. Location

The Alton Study Site is located in the southwestern corner of the State of Utah in Kane County, approximately 20 miles north northeast of Kanab. It consists of 2,640 acres in secs. 8, 17, and 18 of T. 40 S., R., W4-1/2, and sec. 13, T. 40 S., R. 5 W. The entire surface acreage and the subsurface minerals are federally owned.

B. Historical Summary

The Basket Makers inhabited the area as early as 2000 B.C. They were followed by the Puebloans, who cultivated fields and built "Cliff Dweller" houses. Kanab is built on the site of ancient Puebloan farms, and in Sand Canyon and Johnson Canyon, ruined houses are fairly well preserved. The Puebloans were followed by the Piutes, who were farming when the first white settlers arrived in the area in 1858. Evidence of remnant dwellings and pictorial writings indicates that the Indians worked the valley bottoms producing cereal crops. As the white man moved into the region, livestock grazing became the primary use of these lands. Archeologic and cultural sites are common in the general area, but within the boundaries of the study site, none of significance have yet been identified.

A large flood occurred on Kanab Creek in July 1883 that flooded the farmland and scoured out a broad channel far below the level of the irrigation ditches. In 1884 and 1885, floods occurred daily for three or four weeks. The Kanab Creek streambed was cut down about 60 feet, with a width of 70 feet, for a distance of 15 miles in the vicinity of Kanab. Protection from increased floodflows and sediment from the surface mined areas must be provided for.

C. Economy

The economy of the area is based primarily on agriculture. Major income is derived from the sale of livestock and livestock products. Farms produce primarily livestock feed and the area proposed to be surface mined is used for rangeland in support of these livestock enterprises.

If 400 acres a year are surface mined, and if it requires three to five years to reestablish vegetation, there would be 1,600 to 2,400 acres of rangeland removed

from production at any one time. The present carrying capacity of much of this rangeland is low, suffering from overgrazing of past years. Reclaimed land, properly managed, could be more productive than under existing conditions. It may be advisable to accelerate the improvement of other rangeland areas to compensate for the early losses.

Kane County is sparsely populated with a 1970 population of 2,318 people, a decrease of 349 people over the past decade. The municipalities of the area generally have adequate water supplies for moderate growth. However, a sudden influx of people, as could be expected with a new industry, could have a significant impact on the social and economic structure of the area and could tax presently available municipal water supplies. A study of these offsite effects and recommendations to alleviate them should be conducted by a Federal or State agency.

D. Fish and Wildlife

There are no perennial waters located on the study site. Runoff, resulting from snowmelt and rainstorms, flow into Skutumpah Creek and thence into Johnson Wash. Both of these drainages are intermittent and consequently do not support fish.

The primary species of wildlife which occupy the general area are Chukkar partridge, wild turkey, sage hen, mule deer, and cougar. Other surface resources include pinyon pine, juniper, oak, sagebrush, short grasses, and other mountain shrub types. Their primary value is in providing wildlife and livestock forage, shelter, and aesthetics. Recreation is primarily in the form of sightseeing with rock hounding and hunting following. The area is used for winter range for deer migrating from the higher areas. A loss of range in the early years could be expected. The revegetation of the area should include provision for replacement of browse and inclusion of shelter belts to support the wildife population. It will be necessary to protect new vegetation from overgrazing.

E. Climate

The climatological data taken from the published records of the National Weather Service for Alton, Utah, are shown on Table 1. The elevation of the station

Table 1

ALTON* - CLIMATOLOGICAL DATA
PRECIPITATION
1941 - 1970

Month	Normal Precip. (inches)	Departure from Normal				
		+10%	Over -30%	Over -60%	Over +30%	Over +60%
		Percent of Time				
Jan.	1.90	12	35	18	29	18
Feb.	1.49	12	41	29	29	18
Mar.	1.48	18	29	18	24	18
Apr.	1.25	6	41	35	24	12
May	0.78	7	47	33	27	27
June	0.64	11	42	37	32	26
July	1.43	19	31	19	38	38
Aug.	1.94	0	29	16	53	47
Sept.	1.23	12	41	29	41	29
Oct.	1.19	6	59	47	12	18
Nov.	1.26	6	24	24	59	41
Dec.	1.79	24	41	41	24	6
Total	16.38					
Average		11.1	38.3	28.8	33	24.8

TEMPERATURE

Month	Mean 1941-1970	Average Maximum 1966-1970	Average Minimum 1966-1970	Average 1966-1970	Departure from Normal	Days Over 90°F	Days Under 32°F
Jan.	27.1	40.8	15.5	28.1	+1.0	--	30.8
Feb.	29.7	43.6	17.2	30.4	+0.7	--	27.6
Mar.	33.2	48.3	21.3	34.8	+1.6	--	30.4
Apr.	42.2	56.0	24.6	40.3	-1.9	--	28.0
May	50.5	68.9	34.6	51.8	+1.3	--	11.2
June	58.4	75.6	41.3	58.5	+0.1	.8	2.6
July	66.2	82.8	49.8	66.3	+0.1	1.2	--
Aug.	64.5	81.2	49.2	65.2	+0.7	1	0.2
Sept.	58.0	73.4	40.7	57.1	-0.9	--	2.4
Oct.	48.2	62.2	31.3	46.7	-1.5	--	16.6
Nov.	36.9	51.7	24.6	38.2	+1.3	--	27.6
Dec.	29.5	39.9	14.5	27.2	-2.3	--	30.8
Annual	45.4	60.4	30.4	45.4	0	3	208.2

* Elevation of station = 6980 feet mean sea level.

is 6980 feet, while the elevation of the study area ranges from about 6500 to 7000 feet. The total precipitation within the study area is probably similar to that of the Alton station. However, the extreme variation in frequencies and intensities of individual storms is of concern as these present a high erosion hazard and severe flooding often results. Five rain gages were established in the area and the results of these findings are presented in the Hydrologic Study Chapter. It was concluded that there is a need to establish rain gages in the study area rather than rely on data from nearby weather stations and that these need to be operated over a period of several years. This is being accomplished through a study being initiated in fiscal year 1976 by the U.S. Geological Survey.

The mean annual rainfall at the Alton station is 16.38 inches. May and June are normally the driest months of the year, while 28 percent of the annual precipitation occurs during the growing months of July, August, and September. The precipitation during this period often occurs as localized intense storms of short duration, resulting in high rates of runoff with attendant erosion hazard. The frost-free period receives normal precipitation about 50 percent of the time. Twenty-five percent of the time the first free periods are relatively dry, receiving less than 40 percent of normal precipitation.

The mean annual temperature is 45.3 degrees. The maximum of record is 95 degrees and the minimum -20 degrees. The average frost-free period is 120 days, with the maximum being 151 days and the minimum 73 days. Weather service information for the area shows the mean annual lake evaporation rate is about 54 inches.

1. Effect of Weather on Site Reclamation

The average precipitation during the growing season should be adequate to support establishment of vegetation. However, the extreme variability from year to year and localized and intense nature of individual storms present problems. To this is added the relatively slow permeability of the soils in some parts of the area, combined with slopes frequently exceeding 15 percent. Consequently, until adequate cover is reestablished after mining, the erosion hazard will be severe in much of the area. Special seedbed preparation, as discussed later, will be necessary

to minimize erosion and to promote the infiltration of the available moisture to support the establishment of vegetation. Once an adequate grass cover is established and properly managed, the erosion hazard should be improved over present conditions.

Based on monthly precipitation records of the Alton station for the years 1954 through 1970, and assuming proper seedbed preparation, it is probable that without irrigation vegetation would be successfully established in about one-third of the seeding efforts. There would be about an even chance of establishing some vegetation in about another one-third of the seeding efforts depending on the timeliness and distribution of the precipitation, and the remaining one-third of the seedings would most likely result in near complete failures. Failures would be about equally divided between the initial season of planting and the following spring. Failures would result in increased erosion requiring some reshaping of the area, the reestablishment of a seedbed and reseeding. The alternative would be supplemental irrigation.

III. PHYSICAL PROFILE

III. PHYSICAL PROFILE

A. Topography

In southern Utah and northern Arizona, the dominant topographic features are two platforms, each thousands of square miles in area. The lower platform is the Kanab Plateau which extends from Kanab eastward toward the Paria River, southward to border the Colorado River, and northward to the Vermillion Cliffs near Kanab, Utah. Towering above it is the Paunsaugunt Plateau that extends northward into central Utah. Between the platforms are four steps or terraces: the lowest, the Kanab Plateau, is in an area of broad flat valleys, east-west trending flat ridges, and isolated mesas outlined by steep cliffs. Streams originating in the Vermillion Cliffs cross the northern part of the plateau in shallow trenches. The next highest step is the Wygaret Terrace which extends northward some 10 to 12 miles from the Vermillion Cliffs' crest to the base of the White Cliffs. Its surface is quite even, varying in elevation from 6000 to 6600 feet. A few rounded knobs are evident on the surface and its short canyons are cut a hundred or more feet deep. The third step is the Skutumpah Terrace, a broad belt of generally flat land bordered by the White Cliffs on the south and the Glendale Bench on the west, with surface elevations up to 7000 feet. The Alton Amphitheater is the next step to the north which is bordered on the northeast by the Paunsaugunt Plateau, with elevations up to 9000 feet.

The study area is part of the Alton Field located on the Skutumpah Terrace. It occupies a transitional zone between the foothill lands and the mountains, shrub, and ponderosa pine region. The elevations are from 6400 feet on the southern portion of the area rising to 6900 feet along the northern boundary.

Thompson Creek runs north to south near the western border of the area and Skutumpah Creek flows through the bottom of a comparatively wide flat alluvial valley along the east boundary of the area. These drainages head in the Pink Cliffs south of Bryce Canyon National Park. They are tributary to Johnson Wash which is the principal tributary of Kanab Creek. Kanab Creek flows into the Colorado River.

The topography of the area is one of sharply contrasting relief. Fault trends are northwesterly and displacement ranges from a few feet to about 100 feet. The topography is broken with gently sloping valleys and plateaus joined together by steep slopes often exceeding 40 percent. Erosion is active resulting in numerous drainage gullies and channels dissecting the area. The predominant slope rises from south to north at an average of three to eight percent continuing beyond the study area to the Pink Cliffs.

B. Soil

1. General Characteristics of Soils of the Study Area - Order, Suborder, and Great Soil Group in 7th Approximation Terminology (if available)

The 7th Approximation classification was determined for 13 soil profiles exposed by backhoe excavation. The profile locations are shown on Drawing No. 1224-0A-300-1, preceding page 53. Entisols, Mollisols, Alfisols, and Inceptisols are Soil Orders identified in the study area. The classification by order, suborder, great group, subgroup, and family is presented on Table 2. Identification of the 13 profiles by 7th Approximation criteria was made by the Soil Conservation Service.

These profiles were not classified at the series level. Instead, the soils were grouped around profiles that were considered to be similar in texture, structure, depth, and chemical characteristics. Recognizing that within this grouping, soils with other characteristics are included. These groupings are identified as "soil associations."

Fourteen soil associations were mapped. Profiles representing 10 of the soil associations were found within the 13 profiles exposed in the backhoe pits. Detailed physical and chemical laboratory data have been developed which characterize these 10 profiles.

The remaining four soil profiles are based on field descriptions including texture, structure, consistency, and color. There are no laboratory data developed for these profiles. Descriptions of the 14 soil associations are identified in Figure 1 as Nos. 4001 through 4010, Nos. 4013 through 4015, and No. 4017 (18 pages appended). Their distribution is shown on Drawing No. 1224-OA-300-44.

Table 2

GENERAL CHARACTERISTICS OF SOILS OF THE STUDY AREA
SOIL TAXONOMY

7th Approximation Terminology - U.S. Department of Agriculture

Master Site	Order	Suborder	Great group	Subgroup	Family
Pit 1	Entisols	Fluvents	Ustifluvents	Typic Ustifluvents	Coarse-silty, mixed, (calcareous) mesic
Pit 2	Entisols	Orthents	Ustorthents	Typic Ustorthent	Loamy-skeletal, mixed, (calcareous) mesic
Pit 3	Mollisols	Ustolls	Argiustolls	Pachic Argiustolls	Fine-loamy, mixed, mesic
Pit 4	Mollisols	Ustolls	Argiustolls	Pachic Argiustolls	Fine-loamy, mixed, mesic
Pit 5	Mollisols	Ustolls	Argiustolls	Pachic Argiustolls	Fine, mixed, mesic
Pit 6	Alfisols	Ustalfs	Haplustalfs	Typic Haplustalfs	Fine over loamy-skeletal, mixed, mesic
Pit 7	Entisols	Orthents	Ustorthents	Typic Ustorthent	Fine, mixed, (calcareous) mesic
Pit 8	Inceptisols	Ochrepts	Ustochrepts	Udic Ustochrepts	Coarse-silty, mixed, (noncalcareous) mesic
Pit 9	Mollisols	Ustolls	Argiustolls	Typic Argiustolls	Fine-loamy, mixed, mesic
Pit 10	Entisols	Fluvents	Ustifluvents	Vertic Ustifluvents	Fine, montmorillonitic, (calcareous) mesic
Pit 11	Mollisols	Ustolls	Haplustolls	Fluventic Haplustolls	Fine-loamy, mixed, mesic
Pit 12	Entisols	Orthents	Ustorthents	Typic Ustorthent	Fine-loamy, mixed, (calcareous) mesic
Pit 13	Mollisols	Ustolls	Argiustolls	Typic Argiustolls	Fine-loamy, mixed, mesic

2. Unified Soil Classification

The engineering properties of the materials exposed in the 13 backhoe pits were identified according to the "Unified Soil Classification System." These descriptions are presented in Figure 2 (15 pages appended).

3. Description of Principal Natural Soil Bodies

Soils in the study area are formed on mountainous terrain. Present relief reflects major faulting, water deposition, and erosion of thick alluvial and marine deposits. Surface relief varies from extremely sharp, steep slopes between higher-lying lands and drainageways to gentle sloping terrace remnants of a former large pediment deposit from the higher mountains to the north.

On this highly variable terrain, 14 soil associations are mapped. Figure 1 contains 17 soil profile descriptions. Each profile has been identified with one of the 14 soil associations. The soil association to which a profile belongs is identified for each profile. Locations of the soil associations are shown on Drawing No. 1224-OA-300-44.

4. Soil Associations - Typical Profile Descriptions

a. 4001

This soil association represents 10 percent of the study area. Pit No. 6, Figure 1, is typical of the majority of the soils in this association. According to the Bureau of Land Management Manual 7312, these soils are moderately deep (20 to 40 inches). The surface or "A" horizon, is a relatively thin, light yellowish-brown, weak crumb, soft, very fine sandy loam. The subsoil, or "B" horizon, has a strong brown color grading into a yellowish-red, moderate subangular blocky, very hard, loam. Underlying the soil profile are thick strata of gravel, cobble, and stone.

Available water-holding capacity is estimated at about five inches, based on soil texture and an average depth of 30 inches. Cation exchange capacity at pH 8.2 averages about 15 meq/100 grams. Salinity of the saturation extract is very low, less than 0.35 millimhos centimeter. Sodicity is not a problem most commonly measured; pH values ranged from 6.0 to 7.0. Wider ranges undoubtedly exist in the mapping unit. Internal drainage is considered very good. However, the gravel strata are underlain by shale which transmits water very slowly. Gravel, cobble, and stone are found on the surface, both scattered and in heavy concentrations.

E. 1,785,000 E. 1,787,000 E. 1,790,000 E. 1,792,500 E. 1,795,000 E. 1,797,500 E. 1,800,000 E. 1,802,500 E. 1,805,000 E. 1,807,500 E. 1,810,500

R. 5 W. R. 4 1/2 W. R. 4 1/2 W. R. 4 W.

N. 337,500 N. 335,000 N. 332,500 T. 40 S. N. 330,000 N. 327,500 N. 325,000 N. 322,500

NOTE
Coordinate base is taken from Utah International Inc grid system

SCALE OF FEET
1000 0 1000 2000 3000

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
EMRIA PROJECT
UTAH

ALTON COAL FIELD
SOIL ASSOCIATIONS

COMPILED SUBMITTED
DRAFTED RECOMMENDED
CHECKED APPROVED

BOULDER CITY, NEVADA MARCH 5, 1975 | 1224-0A-300-44

b. 4002

This soil association represents five percent of the study area. Pit No. 1 is in a very active alluvial bottom. These soils are deep to very deep (40 to <60 inches). Surface horizon is relatively thick, brown to dark brown, weak subangular blocky, sandy loam. These soils are recent or youthful, therefore a "B" horizon has not developed. The substratum, or "C" horizon, is a pale brown color throughout the greater part of the horizon grading to brown in the lower depth. Its texture is a gritty (10 percent gravel) weak subangular blocky, sandy loam.

Strata high in gravel, cobble, and stone may occur at random in the profile. In profile 1, such a stratum is 42 inches thick, extending from 66 to 108 inches.

Available water-holding capacity is estimated at about six inches. Cation exchange capacity was not determined but is considered normal. Salinity and sodicity concentrations are low and therefore will not adversely affect plants considered for revegetation. Internal drainage of the soil profile is considered very good.

Gravel of varying sizes is found on the surface. Gravel bars consisting of gravel, cobble, and stone abound in this soil association.

c. 4003

This soil association represents nine percent of the study area. Pit No. 10 is typical of the soils in this association. Soils are very deep (<60 inches) alluvial soils. However, shale is the parent material for much of this alluvium.

The surface, or "A" horizon, is a moderately thick, grayish-brown, moderately fine crumb, soft, silty clay loam. The substratum, or "C" horizon, is white to light gray, moderately coarse prismatic to subangular blocky, very hard, silty clay.

Available water-holding capacity is estimated at about eight inches. Soil moisture retained averages about 18 percent at 15 bars, and is shown on Table 4 for this profile. (Fifteen bars is generally accepted as the tension above which many agricultural plants cannot extract moisture from the soil.)

Cation exchange capacity averages about 35 meq/100 grams. Salinity of the saturation extract is 0.8 millimhos or less to 55 inches; below this depth a conductivity of 5.5 millimhos is recorded. Sodicity is not a problem; measured

soil paste pH values range from 7.5 to 7.8. Wider ranges undoubtedly exist in the mapping unit.

Internal drainage is expected to be very slow. Permeabilities of fragmented samples were measured at < 0.06 inch per hour. A few gravel and small gravel bars lie on the surface of these soils.

d. 4004

This soil association represents one percent of the study area. Laboratory data are not available for soils of this association. Soils are on very steep slopes, 70 percent and greater. They are confined to a relatively small acreage in the southeast corner of Section 17.

This area is rough and broken. It is characterized by steep slopes and sharp ridgetops. Huge sandstone boulders are lying on the surface or embedded in the soil. Sandstone ledges and thick strata of shale are also exposed. Although there are considerable differences in fine materials and in their depth over the more consolidated materials, a mantle of yellowish-brown fine sandy loam up to several feet thick covers much of the area.

e. 4005

This soil association represents three percent of the study area. Pit No. 11 is representative of the majority of the soils in this association. These soils are very deep (> 60 inches). The surface, or "A" horizon, is moderately thick, brown, moderate fine crumb, soft, silt loam. The substratum, or "C" horizon, to 60 inches is light gray, fine to medium subangular blocky, very hard, clay loam.

Underlying the soil profile are thick strata of gravel and cobble. Available water-holding capacity is estimated at about eight inches. Cation exchange capacity averages about 30 meq/100 grams. Salinity of the saturation extract is low to very low. The surface six inches of soil has a concentration of 1.28 millimhos/centimeter; below six inches, the concentration is about 0.5 millimhos/centimeter. Sodicity is not a problem. SAR values are very low. Measured saturated soil paste pH values range from 7.5 to 8.0. Internal drainage of the soil profile is considered good. Gravel of varying sizes is found both scattered on the surface and as heavy concentration of gravel, cobble, and stone.

f. 4006

This soil association represents four percent of the study area. Pits Nos. 3 and 4 are representative of soils in this association. Laboratory analyses were made on soil samples from profile 3. Soils are moderately deep to deep (20 to 60 inches). The surface, or "A" horizon, varies from thin to moderately thick, dark brown, moderate crumb, soft, very fine sandy loam to silt loam. The subsoil, or "B" horizon, is well developed. It is brown, moderate to strong subangular blocky, very hard, loam and clay loam.

Underlying the soil profile are thick strata of gravel and cobble. Available water-holding capacity is estimated at about 6.0 inches. Cation exchange capacity averages 17 meq/100 grams. Salinity of the saturation extract is low, less than 0.65 millimhos. Sodicity is not a problem. SAR values are very low; measured pH values of the soil paste range from 6.4 to 7.1.

Internal drainage of the soil profile is considered to be good. Disturbed permeability measurements for profile 3, in Table 4, show good stability with rates ranging from near 0.8 inch per hour in the surface soils to an average of about 0.15 inch for the "B" horizon.

Gravel of varying sizes is found on the surface. Concentrations of cobble, gravel, and stone are common, especially along the small waterways as deposition from local storm runoff.

g. 4007

This soil association represents 11 percent of the study area. Pit No. 5 represents soils in this association. Soil is moderately deep (20 to 40 inches). The surface, or "A" horizon, is moderately thick, brown, weak subangular blocky, soft. very fine sandy loam. The subsoil, or "B" horizon, is about 20 inches thick, dark brown, moderate prismatic to subangular blocky, very hard, clay.

The soil profile is developed on a yellowish, very hard shale.

Available water-holding capacity is estimated at 3.5 inches. Cation exchange capacity of the "A" horizon at pH 8.2 is about 10 meq/100 grams. The CEC of the "B" horizon was nearly 30 meq/100 grams.

Salinity of the saturation extract is low, 0.28 to 0.53 millimhos/centimeter. Sodicity is not a problem. Reaction of the soil paste ranges from pH 6.3 to 7.9. Wider ranges may be expected within the mapping unit. Internal drainage is very slow. Surface gravels are common; areas of concentrated gravel and cobble are also present.

h. 4008

This soil association represents eight percent of the study area. Pits Nos. 9 and 13 are representative of the soils of this association. According to the Bureau of Land Management Manual 7312, these soils are moderately deep (20 to 40 inches). The surface, of "A" horizon, is a moderately thick brown to dark brown, fine platy to weak subangular blocky, soft, fine sandy loam. The "B" horizon is strongly developed, grayish-brown, yellowish-red to red, weak to moderate subangular blocky, very hard, loam through silty clay loam.

Underlying the soil profile are thick strata (>80 inches thick) of gravel, cobble, and stone.

Available water-holding capacity is estimated at from 3.5 to 5.5 inches. Cation exchange capacity of the "A" horizon is about 10 meq/100 grams while the finer textured "B" horizon has an average capacity of about 15 meq/100 grams. Salinity is very low, averaging about 0.50 millimhos centimeter. Sodicity is not a problem; SAR values are very low and pH values of 6.7 to 7.0 are measured for profile 13.

Physical and chemical data indicate that the internal profile drainage is very good.

Gravel is found scattered on the surface. There are heavy surface concentrations of gravel, cobble, and stone found at random and concentrated in rather extensive bodies. Cobble and stone concentrations are particularly heavy around the edges of the terraces with which these soils are associated. In width, these concentrated bands of cobble and stone extend from 50 to 200 feet into the terrace from the outer edge.

i. 4009

This soil association represents six percent of the study area. Laboratory data are not available for soils of this association. Soils lie on very steep slopes (25 to >50 percent). They are coarse because of heavy concentrations of gravel and cobble. Surface soil is moderately thick (20 to 40 inches), coarse (70 to 80 percent gravel and cobble) brown, crumb, soft, gravelly loam. Below six to eight inches, the soil is dark grayish-brown, subangular blocky, coarse, very gravelly, loam. This association has a heavy surface cover of gravel, cobble, stone, and boulders. Large outcrops of sandstone are common.

The principal difference between this soil association and No. 4014 is in depth over shale. Undoubtedly shale underlies much of the area occupied by this association, however, at a relatively greater depth than in association 4014.

j. 4010

This soil association represents nine percent of the study area. Laboratory data are not available for soils of this association. Soils occupy slopes ranging from 5 to 40 percent.

Soils are moderately deep (20 to 40 inches) light clay loams to light clays. Surface soil is relatively thin, yellowish-brown, subangular blocky, soft, gravelly (40 percent) light clay loam. Subsoil is pale brown, strong subangular blocky, gravelly (30 percent) light clay.

The site of this observation was on a 17 percent southeast slope. Ninety percent of the ground surface is covered by gravel and cobble. Embedded sandstone boulders larger than two feet long are exposed at the surface.

k. 4013

This soil association represents one percent of the study area. Pit No. 8 is representative of this rather limited soil association. Soils are moderately deep (20 to 40 inches) over highly weathered sandstone in situ. The surface, or "A" horizon, is relatively thick, pale brown, weak subangular blocky, slightly hard, very fine sandy loam. Subsoil is light yellowish-brown, moderate subangular blocky, very hard sandy clay loam.

Underlying the soil profile is a highly weathered sandstone.

Available water-holding capacity is 4.5 inches. Cation exchange capacity of the surface soil is 8.5 meq/100 grams and of the subsoil 15 meq/100 grams. Salinity and sodicity are not a problem. The salinity of the saturation extract of the surface soil is 0.75 millimhos and lower in the subsoil. pH values of 6.3 were measured for both the "A" and "B" horizons. Internal drainage is very good; some restriction may occur in movement through the weather bed sandstone.

l. 4014

This soil association represents seven percent of the study area. Laboratory data are not available for soils of this association. These soils lie on very steep slopes (25 to >50 percent). Soils are moderately deep (20 to 40 inches), brown, gravelly and cobbly (75 percent gravel and cobble), loam overlying shale. The shale is very slowly permeable. Typically the surface of this soil association has a very heavy gravel, cobble, stone, and boulder cover. Up to 90 percent is covered by rock debris and large sandstone outcrops are common.

m. 4015

This soil association represents nine percent of the study area. Pits Nos. 2 and 12 represent this soil association. Soils in both profiles are highly stratified and extremely variable within even the limited distance of a backhoe test trench. Soils are shallow (10 to 20 inches). The surface horizon is relatively thin, brown, weak, crumb, loose, gravelly (60 percent), fine sandy loam.

The substratum is composed of pale brown and brown, gravelly (80 percent), fine sandy loam. In Pit No. 12, shale is exposed high in the profile. Underlying the soil profile are thick strata of gravel, cobble, and stone.

Available water-holding capacity is low, probably less than 3.0 inches. Cation exchange capacity varies from 18 to 21 meq/100 grams. Salinity is less than 0.60 millimhos. Sodicity is not a problem; pH value of the soil paste was measured at 7.8. Internal drainage of the profile is good to excessive.

Heavy surface concentrations of gravel, cobble, and stone cover the surface.

n. 4017

This soil association represents 17 percent of the study area. Pit No. 7 is representative of much of this soil association. According to the Bureau of Land Management Manual 7312, these soils are very shallow (<10 inches). The surface, or "A" horizon, is relatively thin, light olive gray, moderate fine granular, hard, silty clay. The substratum, or "C" horizon, is light gray, subangular blocky to prismatic, very hard, silty clay. Some weathering related to soil formation has taken place to about 36 inches. Underlying this is shale.

Available water-holding capacity is 5.0 inches. Cation exchange capacities of 41.0 meq/100 grams were measured for the surface soil and an average of about 35.0 meq/100 grams in the substratum.

Moderate concentrations of salts are present in the profile. Gypsum crystals occur as thin sheets along cleavage lines. pH values of the soil paste range between 7.5 and 7.9. Wider ranges in values undoubtedly occur within the mapping unit.

Internal drainage is very slow. The saturation percent is high (see Tables 3 and 4). Bulk densities are high. Since these shale materials are exposed through erosion of the coarse pediment deposits, remnants of the pediment deposits are still found in this soil association. Surface gravel and cobble are common.

5. Soil Inventory

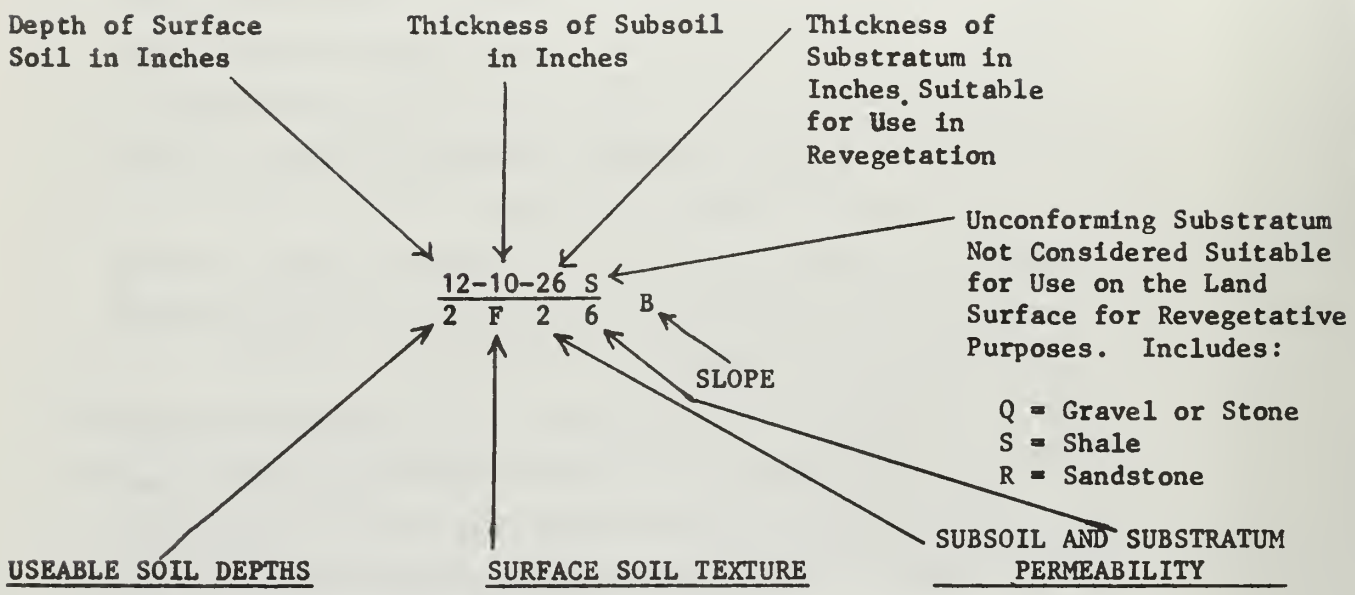
The soil inventory was developed through field investigations using the Soil Mapping Legend, Figure 3. Through the legend, the surveyor identified and grouped soils of similar characteristics. This grouping formed mapping units. These mapping units are shown on Drawing No. 1224-OA-300-43. Characteristics of each mapping unit are identified by use of the fractional symbol shown in Figure 3. From the standpoint of soil resource evaluation for reclamation of disturbed lands, the fractional symbol provides valuable soil information.

a. Mapping Symbol

Interpretation of the mapping symbol is quite straightforward. The denominator does not require clarification. Factors in the numerator may puzzle the reviewer somewhat: therefore, a brief discussion is in order.

Figure 3

SOIL MAPPING LEGEND



USEABLE SOIL DEPTHS	SURFACE SOIL TEXTURE	SUBSOIL AND SUBSTRATUM PERMEABILITY
1 Very deep, over 60"	V Very heavy: 60 percent or more clay.	1 Very slow
2 Deep, 36-60"	H Heavy: Clay, silty clay, sandy clay, h. clay loam.	2 Slow
3 Moderately deep, 20-36"	F Moderately heavy: Silty clay loam, silt	3 Moderately slow
4 Shallow, 10-20"	M Medium: Silt loam, loam, very fine sandy loam.	4 Moderate
5 Very shallow, less than 10"	S Moderately light: Fine sandy loam, sandy loam, heavy loamy sands.	5 Moderately rapid
	L Light: Loamy very fine sand, loamy fine sand, loamy sand.	6 Rapid
	C or Q Coarse: Sandy, coarse sand, gravelly sand.	7 Very rapid

SLOPES

A	0-5	percent
B	5-15	percent
C	15-25	percent
D	25-40	percent
E	40+	percent

The numerator, when completely filled out, contains information on the thickness of the surface soil: thickness of the subsoil: and thickness of the substratum, suitable for revegetation. It also identifies the unconforming substrata (that is, gravel, shale, or sandstone) if the soil profile is less than 60 inches thick. Summation of the numbers in the numerator provides the user with information regarding the total depth (to 60 inches) of soil suitable for reconstruction of a soil medium for revegetation. If one of the soil zones is missing, the symbol will be short in that entry. A symbol containing a number and a letter in parentheses, such as (14Q) or (25S), has been used. In the case of (14Q), this means that there are 14 inches of soil containing considerable gravel, cobble, or stone. Where the symbol (25S) is used, 25 inches of shale have weathered and can be used for revegetation.

b. Need for Additional Study

Prior to disturbing the soils in this area, this soil inventory should be refined. Heavy pinyon-juniper stands were a great obstacle in making accurate traverses. The section corners and quarter corners are brasscapped throughout the area; however, little use could be made of these points as foresights because of the thick tree growths. Flagging these corners with extra tall poles and clearing lines between the brass caps would increase accuracy in making final plans for land restoration.

While the mining operations are in progress, but before the mining reaches a tract, each 10-acre tract should be inventoried to provide detailed information to insure preservation of all suitable soil material.

6. Greenhouse Studies

Under contract with Colorado State University, greenhouse studies have been completed. Western wheatgrass (agriophyron smithii Var. Arriba) was grown in growth chambers in pots containing 2,000 grams of overburden sample. Detailed accounts of these studies are contained in a report entitled "Characterization of Strata Overlying Coal Seams as Plant Growth Media," dated May 1975, prepared by Jim T. Herron and W. A. Berg, Agronomy Department, Colorado State University, Fort Collins, Colorado.

Field capacity values were determined for each overburden sample. Each pot was fertilized with nitrogen and phosphorus.

Observations were made of plant appearance and soil conditions. They are recorded in Table 9 (appended). Blackening of leaf tips was noted in both experiments on various samples. Blackened leaf tips were observed and frequency of occurrence, within pots, was recorded as follows:

0- no plants with black leaf tips
1- 1-4 plants with black leaf tips
2- 5-8 plants with black leaf tips
3- 9-12 plants with black leaf tips
4- 13-16 plants with black leaf tips

These blackened leaf tips (5-10 mm) changed to a brown color after one to two weeks. Although the leaf tips died back, there was no evidence of overall yield reduction of plants so affected. Boron toxicity might be responsible for the leaf tip dieback.

Salt crusting and surface cracking in some overburden samples were observed. The degree of salt crushing and surface cracking of the overburden was given the numerical designation as follows:

0- none
1- very slight
2- slight
3- moderate
4- extreme

Roman numerals I and II in Table 9 refer to replications. Duplicate pots were run on all soil and overburden samples for which there was adequate soil material.

When the majority of the plants, in all pots, reached a height of about 10 cm, the number of plants in each pot was recorded and each pot was thinned to 16 plants. The plants were grown for 53 days, from seeding, in the first greenhouse experiment (October 5 to November 27, 1974) and for 52 days in the second experiment (January 26 to March 19, 1975).

Highly productive loam soil was included in both experiments as a standard soil for comparison with all others (Table 9).

The plants were clipped at a height of 2 cm above the surface, washed in 0.05 normal HCl, and rinsed in distilled water. The plants were dried in a forced-air oven at 70°C for 24 hours and then weighed to the nearest 0.01 g.

Large differences in growth occurred. For purposes of this discussion, yields of less than one gram will be considered low; yields of one and two grams, medium; and above two grams, high. Yields for the DH-105 samples were generally high (see Figure 4). However, many of the other samples were highly sodic (ESP greater than 15). Because of the excess sodium, the overburden samples might be expected to produce very little vegetation in the field because they would be almost impermeable to water. With minor exceptions, most of the samples yielded well in the growth chamber (Table 9).

In these studies, overburden samples with higher field capacities generally yielded the most. In the field, under arid and semiarid conditions, these fine-textured soils would be the more droughty because of greater surface runoff and evaporation. Thus, growth differences reported give only an indication of the suitability of the overburden as a plant growth media under controlled greenhouse conditions. When extrapolating these results to field conditions, the physical and chemical characteristics must be evaluated along with the greenhouse data to make reasonably accurate interpretations of the suitability of the overburden material as a plant growth media. When interpretated in this manner, the greenhouse data become a valuable tool in the overall process of evaluating the overburden for reclamation purposes.

7. Laboratory Studies

a. Backhoe Pits

Chemical and physical analyses were made of nine soil profiles exposed in the backhoe pits. These pits were Nos. 2, 3, 5, 6, 7, 8, 10, 11, and 13. Tables 3 and 4 contain the data related to these profiles.

(1) Contents of Table 3 (Appended)

(a) Soil separate sizes - pipette method

(b) Cation exchange capacity - sodium acetate at 8.2 pH

(c) Sodium characterization meq/100 grams

(d) Exchangeable sodium percentage

(e) Sodium adsorption ratio

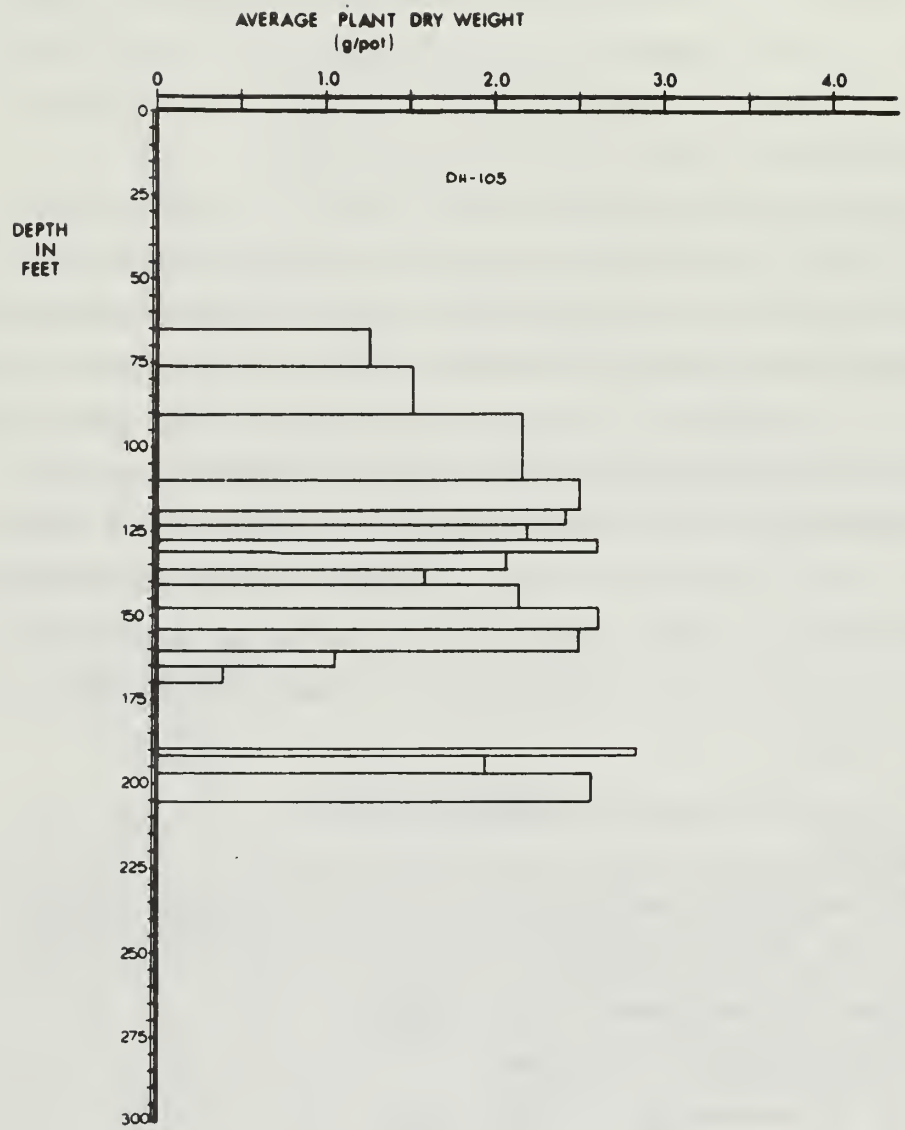


Fig. 4 Yields of western wheatgrass grown on overburden from Alton site in Utah

(f) Settling volume - USBR Laboratory Procedures, Part 517

(g) Exchangeable potassium

(h) pH: paste and 1:5

(i) Saturation percentage

(j) Electrical conductivity - millimhos

(k) Saturation extract data meq/l of common cations and anions

(l) Extractable sodium and potassium - ammonium acetate extraction at pH 7.0

(2) Contents of Table 4 (Appended)

(a) Bulk density - waxed clod method

(b) Estimated lime - observed effervescence with HCl

(c) pH in 0.01 molar calcium chloride - using 10 g of soil + 20 ml of 0.01 M calcium chloride at pH 5.5

(d) Gypsum - footnote 2/ Table 4

(e) Boron - carmine method

(f) Phosphorus p/m - footnote 3/ Table 4

(g) Estimated sulphur - footnote 1/ Table 4

(h) Permeabilities on fragmented samples - 2, 6, and 24 hours

(i) Fifteen-bar moisture percentage - puddled technique ceramic plates

b. Drill Holes - Deep Strata Samples

Screening studies were made of 4 strata in Drill Hole 101; 10 strata of Drill Hole 103; 5 strata of Drill Hole 104; and 17 strata of Drill Hole 105.

Table 5 and 5a contains data for DH-101, DH-103; DH-104, and DH-105.

(1) Contents of Table 5 (Appended)

(a) Depth and thickness of strata in relation to ground surface

(b) Estimated lime - observed effervescence with HCl

(c) pH_2 in 0.01 molar calcium chloride - using 10 g of soil + 20 ml of 0.01 M calcium chloride at pH 5.5

(d) pH 1:5

(e) Electrical conductivity in millimhos 1:5

(f) Settling volume - USBR Laboratory Procedures, Part 517

(g) Estimated sulphur - footnote 1/ Table 4

(h) Gypsum requirement meq/100 grams

(i) Disturbed permeability - 2, 6, and 24 hours

(j) Fifteen-bar moisture percentage - puddled technique ceramic plates

(2) Contents of Table 5a (Appended)

(a) Depth and thickness of strata in relation to ground surface

(b) Laboratory number

(c) Estimated lime - observed effervescence with HCl

(d) pH_2 in 0.01 molar calcium chloride - using 10 g of soil + 20 ml of 0.01 M calcium chloride at pH 5.5

(e) Gypsum - footnote 2/ Table 4

(f) Boron p/m - carmine method

(g) Estimated sulfur - footnote 1/ Table 4

(h) Gypsum requirement meq/100 grams

(i) Fifteen-bar moisture percentage - puddled technique ceramic plates

8. Soil Evaluation - Laboratory Data Interpretation for Vegetative Purposes

a. Pit No. 2

These data indicate these soils are suitable for vegetative purposes. Cation exchange capacity in the 0- to 17-inch depths is higher than other soils with similar physical properties probably because of the presence of organic matter. Organic matter is probably responsible for the higher moisture-retaining percentages observed at 15 bars for the same two samples. Production in the Greenhouse studies was good.

b. Pit No. 3

These soils are well suited to reclamation according to data from this pit. This was confirmed by high yield of Western wheat grass in the Greenhouse studies.

c. Pit No. 5

Settling volumes are surprisingly good. The permeabilities of fragmented samples indicate moisture movement problems exist. The moisture retention at 15

bars is relatively high in the 8- to 25-inch and the 25- to 56-inch zones. With the exception of the surface eight inches, these soils , if placed on the surface, will create problems.

d. Pit No. 6

The profile is well suited for revegetation down to the gravel strata. Below the gravel strata, in the 90- to 114-inch zone, the physical and chemical characteristics of shale show up. Greenhouse data also reflect the shale. The saturation percent is high as is the moisture retention at 15 bars. Disturbed permeability is very low. Greenhouse data are favorable to 16 inches. The depth from 16 to 30 inches shows low yields; however, the Greenhouse data must be discounted.

e. Pit No. 7

Settling volumes are acceptable. Bulk densities are high all through this zone. There are heavy gypsum concentrations in this profile which keep these clays from dispersing. However, the fragment soil permeability is extremely low. Greenhouse data show low yields below the surface six inches.

f. Pit No. 8

Pit No. 8 shows suitable soil conditions to 33 inches. Below 33 inches, the profile consists of highly weathered sandstone. The sandstone was moist when the pit was dug. The soil material came out like unconsolidated sandy loams. Greenhouse data place this profile in the medium yield category.

g. Pit No. 10

The texture of this profile is very fine. Note the very slow permeability. Other data appear favorable. Except for the surface nine inches, the remainder of the Greenhouse data show yields greater than would be expected in nature.

h. Pit No. 11

This profile is suitable. The third depth on the 15-bar moisture retention percentage is slightly high and disturbed permeability is relatively low. The Greenhouse data rate these soils in the medium range.

i. Pit No. 13

This profile looks good. Results of the Greenhouse studies indicate they are well suited for revegetation.

j. Drill Hole 101

Salinity is up moderately at about 5.8 millimhos. The pH's indicate trouble. Settling volumes are good on two samples and poor on two. Gypsum requirement is high.

k. Drill Hole 103

Most settling volumes are extremely high, indicating aggregate instability and low permeabilities. Also, very high sulfur dioxide concentrations characterize this zone. The pH's in the calcium chloride solution are all on the upper to critical limit. Gypsum requirements are high. Permeability of three strata in this profile indicates very poor permeability. Permeability is extremely low. Retention of soil moisture at 15 bars is moderately high.

l. Drill Hole 104

The pH levels in the calcium chloride solution indicate trouble. The pH's of the 1:5 are moderate. The EC's ranged from about 4 to 18 millimhos, fairly high. Shales and sandstone are present in this zone. Settling volumes vary with the material. The sandstone exhibits the low settling volumes. The shales are higher in gypsum requirements. If gypsum were applied in adequate quantities to some of these shale strata, they possibly could be used for revegetation purposes. In the present condition, the moisture retained at 15 bars is relatively high (20 to 30 percent) which indicates fine textures, low permeabilities, and cause for concern in available waters held for the plant.

m. Drill Hole 105

Laboratory Nos. S1.5 and S2.5 have lower settling volumes than depths below, indicating little or no dispersion. Their exchangeable sodium percentages are low. The EC's are relatively high. Textures are silty clays and silty clay loams; cation exchange capacities are 40 to 50 meq/100 grams. These depths may have some value for reclamation revegetation purposes compared with the depths below. The

settling volumes show extremes. There are strata that could be considered for reclamation purposes. Certainly, the majority of the strata should be avoided.

9. Weathering Studies

Weathering tests were conducted on overburden core samples from Kanab, Utah.

The purpose of these tests was to determine which materials would weather (breakdown) sufficiently to allow for their possible use as topsoil in revegetation of strip-mined areas.

A total of 16 core samples was submitted from the Kanab site, and from this number, 8 samples were tested.

a. Laboratory Tests

Duplicate specimens from each core depth were selected for either freeze-thaw or wet-dry tests. A freeze-thaw cycle consisted of the following conditions:

(1) Eight hours at 75°F, 100 percent relative humidity (wetting-thawing)

(2) Sixteen hours (64 hours on weekends) at -10°F (freezing)

For the wet-dry tests, one cycle consisted of the following conditions:

(1) Eight hours at 75°F, 100 percent relative humidity (wetting)

(2) Sixteen hours (64 hours on weekends) at 100°F, 10 percent relative humidity (drying)

Where possible, core specimens about two inches in diameter by two inches high were used. In other cases, several pieces of core samples totaling the approximate same size were used. For testing and handling, the core specimens were placed in one-pint wax cardboard containers (3-3/8 inches in diameter).

Tests were started on January 30, 1975, and 30 weathering cycles were completed on March 14, 1975. During the test period, the specimens were visually examined several times a week to determine what changes had occurred. Results of the visual examinations are summarized in Table 6 (appended). Abbreviations used in the tables are listed in Table 7 (appended).

At the completion of the testing, a percent breakdown value (%BD) was determined for a number of the specimens. This value was obtained as follows:

$$\%BD = \frac{TW - IW}{TW} \times 100$$

TW = Total sample weight
IW = Weight of original sample remaining intact after testing

The %BD is listed in the last column under Remarks in Table 6. However, in general, for samples that exhibited swelling characteristics no %BD was determined.

Results of the weathering tests indicated that, in general, the freezing-thawing condition caused more weathering or breakdown than wetting-drying. This was evident by both visual examination and gradation analyses conducted on several samples after testing.

Based on discussions with Dr. William Berg, Agronomy Department, Colorado State University, concerning soil texture necessary for revegetation, the following samples from the Kanab site meet his criterion of a minimum of 30 percent (by weight) passing the No. 10 screen: K-1F, K-2F, K-4F, K-10F, K-11F, and K-12F.

b. Summary

Laboratory weathering tests involving both freeze-thaw and wet-dry tests were conducted on eight overburden core samples. The purpose of these tests was to determine which materials would break down sufficiently to allow for their possible use as topsoil in revegetation of strip-mined areas.

Results of this study indicate that the freeze-thawing condition is more severe than wetting-drying in that it caused more rapid breakdown of the overburden materials. Although no attempt was made in this study to correlate the laboratory weathering to field weathering, it can be expected that freezing-thawing would also be the most severe of the two conditions in the field. However, the degree of severity would be dependent upon the amount of moisture available at the various sites, especially during snowmelt and runoff when freezing-thawing might occur.

Of the eight samples tested, six exhibited sufficient breakdown to attain the texture required for topsoil, that is, 30 percent by weight of the soil passing the No. 10 screen. In the field, however, these materials, primarily shales, will probably weather at different rates; and this will require various methods of handling, storing, and processing before they are suitable for use as surface material for revegetation.

Some of the samples tested showed swelling characteristics and other deleterious properties that might preclude their use in revegetation. However, such materials might find application in constructing impervious blankets to isolate problem soils during replacement of the overburden materials. Good examples are the silty clay loams and clays in DH-105, shown on Table 3 which have settling volumes ranging from 90 to 500.

One Kanab site sample showed no effects of weathering. This material was well-cemented sandstone. In the field, such materials might find application in the construction of french drains and outslope foundations.

10. Techniques, Procedures, and Standards Used in Soil Investigations

The study area is shown on Drawing No. 1224-OA-300-43. It consists of all or parts of five sections, totaling about 2,640 acres.

On August 18, 1974, by contract with Olympus Aerial Surveys, Inc., Salt Lake City, Utah, the Bureau of Reclamation obtained photography of the study area. The area was flown from east to west on two flight lines consisting of six photographs each. Twelve colored contact prints were delivered to the Lower Colorado Region of the Bureau of Reclamation. Each print was nine inches by nine inches, with sufficient imagery overlap for stereoscopic study.

Soil mapping symbols for use in field mapping are shown on Figure 3.

The field classification was begun in September and completed in early October 1974. Through use of the stereoscope, landscape features were plotted on the aerial photographs prior to initiating the field survey.

Brass mounted section corners and quarter corners are in place throughout the study area. At the time the monuments were placed, witness trees were marked at four points surrounding each monument. Many of these trees were found well marked and legible. Most monuments were found.

Thirteen backhoe pits were dug at representative landscape sites to identify soils and obtain soil samples for laboratory analysis. These profile descriptions are presented in Figure 1.

Three large test trenches were excavated with a bulldozer and four deep holes were drilled. Descriptions of these profiles are in the geology section of this report.

The area was traversed on foot. Numerous profiles were examined in road cuts and along drain banks which supplemented those examined by use of the shovel and auger.

Approximately 40 soil profiles were examined and described in varying detail using hand tools. Many additional probes were made to observe soil profile characteristics generally and provide guidance for mapping interpretations.

11. Determination of Erosion Condition Class (Soil Surface Factors [SSF], BLM Form 7310-12)

There were 22 traverses made to determine the present erosion condition on the land surface in the study area. The evaluation of each traverse is included in Figure 4, BLM Form 7310-12. The number of each traverse is shown on the upper right-hand corner of each form. The general field location of each traverse is shown on Drawing No. 1224-OA-300-33. Shown at each location are the traverse number and the soil surface factors' (SSF) value.

The soil erosion condition classes ranged from slight to severe. There was reasonable correlation between slope groups and the erosion condition classes. The A slopes ranged in severity from 29 to 59, or from slight to moderate. The B slopes ranged from 41 to 53, or moderate. The C slope had only one traverse across it and its value was 36, slight to moderate. The D slopes ranged in values from 52 to 92. However, in the area with a numerical value of 52, was a second traverse whose value was 69. Therefore, reasonable value for the erosion condition classes of D slopes would be critical to severe. The E slope values ranged from 75 to 91. Of the five traverses made, only one was less than 80; therefore, the erosion condition classes of the E slope are considered to be severe. Based on these data, Drawing No. 1224-OA-300-33 was constructed showing four erosion condition classes. BLM Form 7310-12, Figure 4, is included for the 22 traverses.

C. Vegetation, Soil Moisture Retention, and Soil Erodibility Characteristics

1. Vegetation

The presence of a few, widely scattered ponderosa pine indicates that the study site is in the upper portion of the pinyon-juniper zone as shown on Drawing No. 1224-OA-300-49. An unexpected feature of the vegetation is the almost complete absence of grasses and forbs. Throughout this extensive vegetation type, which covers some 65 million acres (Aro, 1971), reduction in fires and heavy use by livestock have caused increases in tree densities and reductions in herbs; however, the almost complete absence of herbs is extremely rare. There is abundant evidence that big sagebrush formerly occupied much more of the site and is now being replaced by pinyon and juniper. Some areas (see sample site No. 6, Table 10) have gambel oak as a prominent understory species, while others (see sample site No. 7) have mountain mahogany as an understory. Mapping techniques used did not permit delineation of these types.

Big sagebrush is present in nearly pure stands and stands with scattered juniper, usually on alluvial soils of moderate relief and slightly finer texture than those occupied by pinyon and juniper.

An additional surprising feature on this site is the high percentages of bare soil; some of these are similar to those found in desert shrub communities. Possible explanations for these high bare soil values may be one or several of the following: (1) inhibitory substances produced by juniper, pinyon, and big sagebrush (Rice, 1974), (2) past heavy use by livestock, and (3) high erosion rates present on much of the area.

2. General Soil Considerations

Reclamation of surface-mined lands will be more successful and accomplished in less time if surface soils are stock-piled and then replaced on the reshaped overburden. Effective use of the surface soils requires a knowledge of their moisture retention characteristic or the relationship between the quantity of moisture in the soil and the forces involved in retaining that moisture.

Table 10--Percent aerial cover of vegetation and percent cover of mulch, bare soil, and rock for vegetation types sampled

Vegetation type.....		Pinyon-Utah juniper						Utah juniper-pinyon			Big sagebrush			
Sample site number.....		2	4	6	7	9	12	3	8	11	1	5	10	13
Species														
Trees														
Juniperus osteosperma	Utah juniper	11.8	4.5	16.0	3.5	16.0	16.3	18.7	17.8	46.7	--	1.0	15.5	4.0
Pinus edulis	Pinyon	33.0	21.0	25.7	8.3	34.5	24.7	1.0	3.0	--	--	--	--	16.0
Shrubs														
Artemisia tridentata	Big sagebrush	--	--	--	--	--	--	--	--	2.2	17.5	26.0	37.8	19.3
Quercus gambellii	Gambel oak	--	--	13.0	--	--	--	--	--	--	--	--	--	--
Cercocarpus montanus	Mountain mahogany	--	--	--	3.0	--	--	--	--	--	--	--	--	--
Grasses														
Bromus tectorum	Cheatgrass	--	--	--	--	--	--	--	--	--	1.2	--	--	--
Algal crust		--	--	2.8	--	--	--	--	8.8	--	--	--	--	3.2
Moss		0.7	--	--	--	0.8	--	--	--	--	--	--	--	2.2
Bare soil		13.0	47.2	23.0	61.0	26.0	3.0	52.0	49.6	23.0	60.5	46.8	24.0	23.8
Rock		14.0	6.8	--	7.0	2.5	21.0	1.5	--	2.2	--	5.7	2.0	--
Mulch		27.5	20.5	19.5	17.2	20.2	35.0	26.8	20.8	26.0	20.8	20.5	20.7	31.5

R. 5 W. R. 4 1/2 W. R. 4 W. R. 3 1/2 W.

T. 40 S.

E. 1,785,000 E. 1,787,000 E. 1,790,000 E. 1,792,500 E. 1,795,000 E. 1,797,500 E. 1,800,000 E. 1,802,500 E. 1,805,000 E. 1,807,500 E. 1,810,500

N. 337,500 N. 335,000 N. 332,500 N. 330,000 N. 327,500 N. 325,000 N. 322,500

SOIL MAPPING LEGEND

Depth of Surface Soil in Inches | Thickness of Subsoil in Inches | Thickness of Substratum in Inches Suitable for Use in Revegetation | SLOPES | Uncontorming Substratum Not Considered Suitable for Use on the Land Surface for Revegetative Purposes. Includes: G - Gravel or Stone, S - Shale, R - Sandstone

Example: 12 - 10 - 26 S / 2 F 2 6 / B

USEABLE SOIL DEPTHS

1 Very deep, over 60
2 Deep, 36 - 60
3 Moderately deep, 20 - 36
4 Shallow, 10 - 20
5 Very shallow, less than 10

SURFACE SOIL TEXTURE

V Very heavy: 60 % or more clay.
H Heavy: Clay, silty clay, sandy clay, h. clay loam.
F Moderately heavy: Silty clay loam, sitl
M Medium: Silty loam, loam, very fine sandy loam.
S Moderately light: Fine sandy loam, sandy loam, heavy loamy sand.
L Light: loamy very fine sand, loamy fine sand, loamy sand.
C or D Coarse: Sandy, coarse sand, gravelly sand.

SUBSOIL AND SUBSTRATUM PERMEABILITY

1. Very slow
2. Slow
3 Moderately slow
4 Moderate
5 Moderately rapid
6 Rapid
7 Very rapid

SLOPES

A 0 - 5 %
B 5 - 15 %
C 15 - 25 %
D 25 - 40 %
E > 40 %

NOTE

Coordinate base is taken from Utah International Inc grid system

1000 0 1000 2000 3000
SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
EMRIA PROJECT
UTAH

ALTON COAL FIELD

SOIL MAPPING UNITS

COMPILED	SUBMITTED
DRAFTED Joe Wadsworth Jr.	RECOMMENDED
CHECKED	APPROVED

BOULDER CITY, NEVADA FEB. 27, 1975 | 1224-0A-300-43

R. 5 W. R. 4 1/2 W. R. 4 W.

T. 40 S.

E. 1,790,000 E. 1,792,800 E. 1,795,000 E. 1,797,300 E. 1,800,000 E. 1,802,300 E. 1,805,000 E. 1,807,500 E. 1,810,500

N. 337,500 N. 335,000 N. 332,500 N. 330,000 N. 327,500 N. 325,000 N. 322,500

SOIL MAPPING LEGEND

Depth of Surface Soil in Inches — Thickness of Subsoil in Inches — Thickness of Substratum in Inches Suitable for Use in Revegetation

Unconforming Substratum Not Considered Suitable for Use on the Land Surface for Revegetative Purposes Includes:
G - Gravel or Stone
S - Shale
R - Sandstone

Example: 12 - 10 - 26 S / B SLOPES / 2 F 2 6

USEABLE SOIL DEPTHS

1 Very deep, over 60
2 Deep, 36 - 60
3 Moderately deep, 20 - 36
4 Shallow, 10 - 20
5 Very shallow, less than 10

SURFACE SOIL TEXTURE

V Very heavy: 60 or more clay
H Heavy: Clay, silty clay, sandy clay, h clay loam
F Moderately heavy: Silty clay loam, sicl
M Medium: Silty loam, loam, very fine sandy loam.
S Moderately light: Fine sandy loam, sandy loam, heavy loamy sand.
L Light: loamy very fine sand, loamy fine sand, loamy sand
C or O Coarse: Sandy coarse sand, gravelly sand

SUBSOIL AND SUBSTRATUM PERMEABILITY

1 Very slow
2 Slow
3 Moderately slow
4 Moderate
5 Moderately rapid
6 Rapid
7 Very rapid

SLOPES

A 0 - 5
B 5 - 15
C 15 - 25
D 25 - 40
E > 40

EXPLANATION

EROSION CONDITION CLASSES
MAP INTERPRETATION AND SYMBOLIZATION

- Slight to Moderate
- Moderate
- Critical to Severe
- Severe

SOIL SURFACE FACTORS - SSF
(BLM FORM 7310-12)

SSF VALUE

0 - 20	Stable
21 - 40	Slight
41 - 60	Moderate
61 - 80	Critical
81 - 100	Severe

T - 10 / SSF - 59 Traverse Number / Soil Surface Factor Value

NOTE
Coordinate base is taken from Utah International Inc. grid system.

1000 0 1000 2000 3000
SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
EMRIA PROJECT
UTAH

ALTON COAL FIELD
SOIL EROSION CONDITION CLASSES

COMPILED _____ SUBMITTED _____
DRAFTED _____ RECOMMENDED _____
CHECKED _____ APPROVED _____

BOULDER CITY, NEVADA FEB. 27, 1973 | 1224-0A-300-33

Explanation

Pinyon-juniper--This extensive type is most common on coarse soils and steep slopes.

Utah juniper-pinyon--On moderate slopes juniper is more abundant than pinyon. Numerous dead big sagebrush plants are common in this type.

Juniper-big sagebrush--On gentle slopes juniper and big sagebrush share dominance.

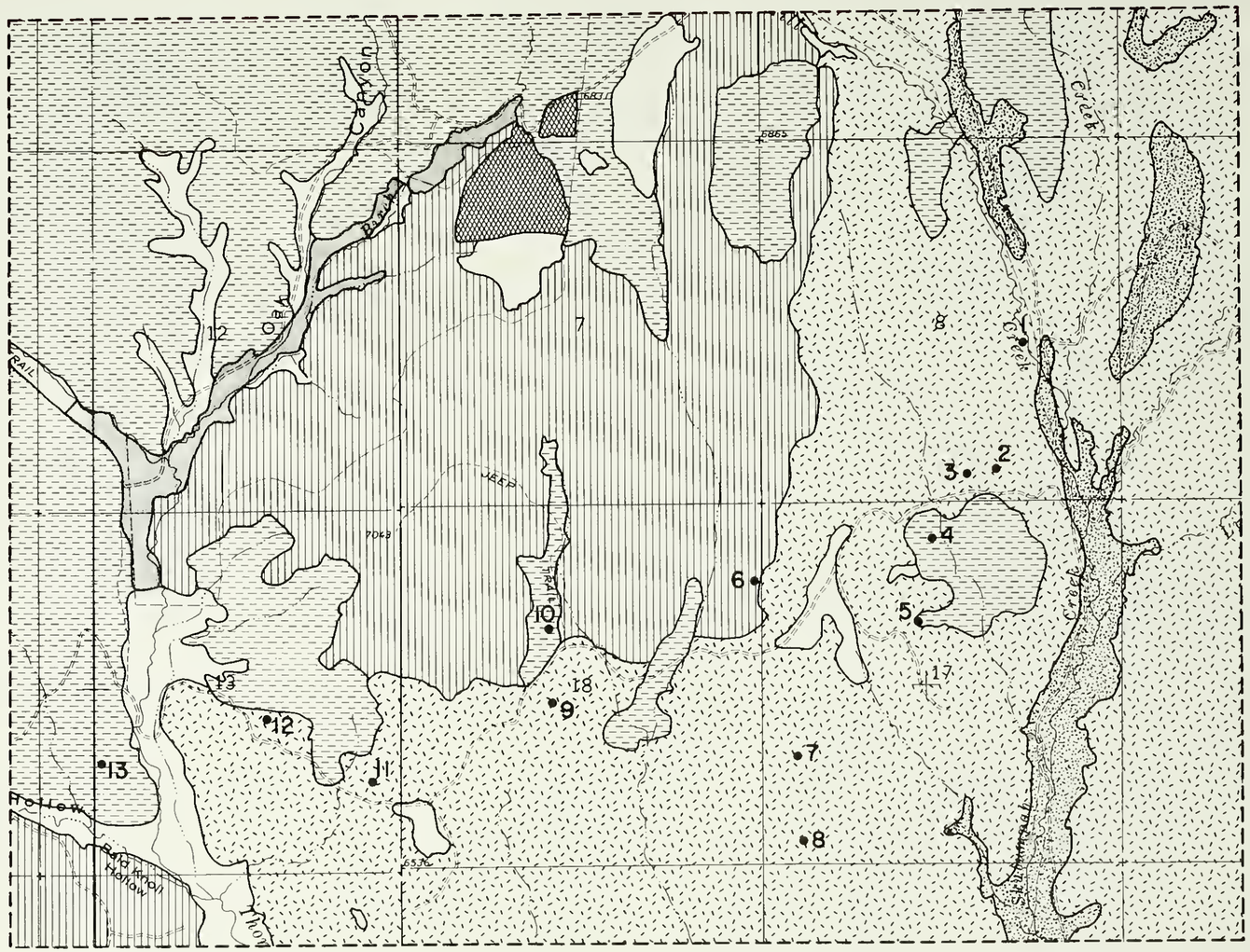
Big sagebrush-juniper--On gentle slopes but in relatively fine-textured soil big sagebrush is more abundant than juniper.

Big sagebrush--On recently deposited alluvium and near stream courses, big sagebrush is the vegetation dominant.

Conversion of pinyon-juniper type to grassland.

Conversion of big sagebrush type to grassland.

• 10 Vegetation and soil sampling locations.



Base from U.S. Geological Survey
Bald Knoll and Skutumpah Creek 7½ minute Quadrangles

1000 0 1000 2000 FEET

VEGETATION MAP OF THE ALTON COAL FIELD STUDY SITE, UTAH - 1974

1224-0A-300-49

The moisture retention characteristic for a soil can be defined if two physical properties are known: (1) a measure of the surface available within a soil for adsorption of moisture as films, and (2) a measure of the porosity of the soil that exists at the time for which the characteristic is to be defined.

Moisture contents may be defined on a weight basis (grams of water per gram of soil) or on a volume basis (cubic centimeters of water per cubic centimeter of soil). Conversions from weight to volume are made through multiplication by the dry bulk density of the soil.

The forces of moisture retention are defined in numerous ways. In this section of the report pF (Schofield, 1935) which is defined as the common logarithm of the height in centimeters of a column of water that requires an equivalent force to support it will be used to simplify computations and permit visualization of the forces as physical dimensions.

For equilibrium conditions, a pF of 1 represents the retention force at a height of 10 centimeters above a water table. At 100 centimeters above a water table, the stress would be pF 2; and at 1,000 centimeters, the equilibrium stress would be pF 3.0.

McQueen and Miller (1974) described a model for snythesizing the soil moisture characteristic from limited data. The curve is divided into segments and a separate mechanism of moisture retention determines each segment. For the range of retention forces from pF 2.5 to 5.0, moisture is retained as films on particle surfaces by molecular adsorptive forces that vary inversely with a power of the film thickness. This segment of the characteristic is a straight line intersecting the zero moisture content axis at pF 6.25 and passing through any valid pF versus moisture-content data points that are known.

For retention forces greater than pF 5.0, the moisture is adsorbed to surfaces in a pseudomolecular structure and the moisture characteristic is cyclic. However, it can be approximated by a straight line between the zero moisture content axis at pF 7.0 and the adsorbed segment at pF 5.0.

For moisture retention forces less than pF 2.9, surface tension forces may add additional moisture in the form of capillary water bodies to the moisture

retained as adsorbed films. This capillary segment of the soil moisture characteristic is unstable, because of alterations in pore-geometry and the effects of a hysteresis loop, so it can only be defined in terms of limits or ranges. However, the probable configuration can be predicted for given sets of conditions.

Synthesis of a typical soil moisture characteristic is illustrated in Figure 6. The adsorbed water segment is defined from one or more data points. In this report all retention data were obtained with the wide range method of McQueen and Miller (1968), but any valid data could be used. The intercept of the adsorbed water segment at pF 6.25 has been established statistically from a large mass of data and should be considered valid for most soils. Structured water (the segment above pF 5.0) can usually be removed from a soil profile only by evaporation near the soil surface, so it need not be considered when computing transpiration. The adsorbed moisture segment is extended to the zero pF axis to indicate the computation for AMC (the maximum adsorbed moisture at a stress of pF zero).

3. Soil Sampling Procedure and Data Presentation

Soil profiles were sampled at locations indicated on the vegetation map shown on Drawing No. 1224-OA-300-49. Samples were obtained for each 10 cm depth increment, examined in the field to define tentative horizon depths, and then sealed for transportation to the laboratory. A moisture-stress sensor (filter paper) was included in each sample.

Vegetation at each sampling site was identified, measured, and photographed to define plant community associations. Photographs of the sites and the associated average soil-moisture characteristics are shown on Figure 7.

The soils hydrologic data are presented in Tables 12a and 12b (appended). Definitions and methods for items reported are as follow:

H = Soil Horizon defined hydrologically and determined during field examination but adjusted where bulk density, electrical conductivity, pH, or root data indicated a change should be made.

1 = That portion of the soil profile that is wetted by capillary or gravity flow during recharge events. The A horizon or leached zone.

2 = That portion of the soil profile that receives moisture after recharge events by displacement of the moisture in the 1 horizon. Moisture movement is usually in the form of film flow. A zone of accumulation of clay and salts. Usually corresponds to the B horizon.

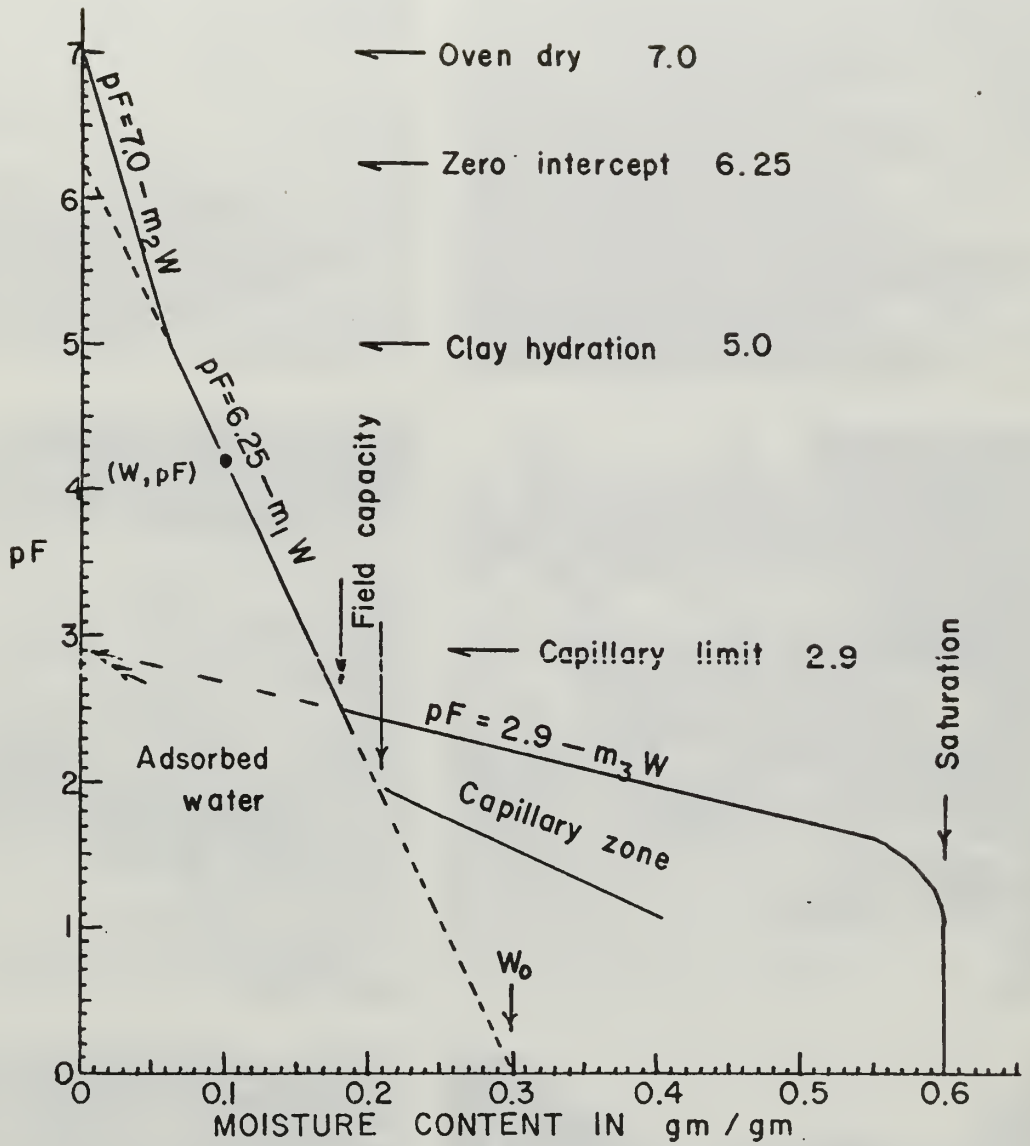


Figure 6 .--Definition diagram for a synthesis of soil-moisture characteristic.

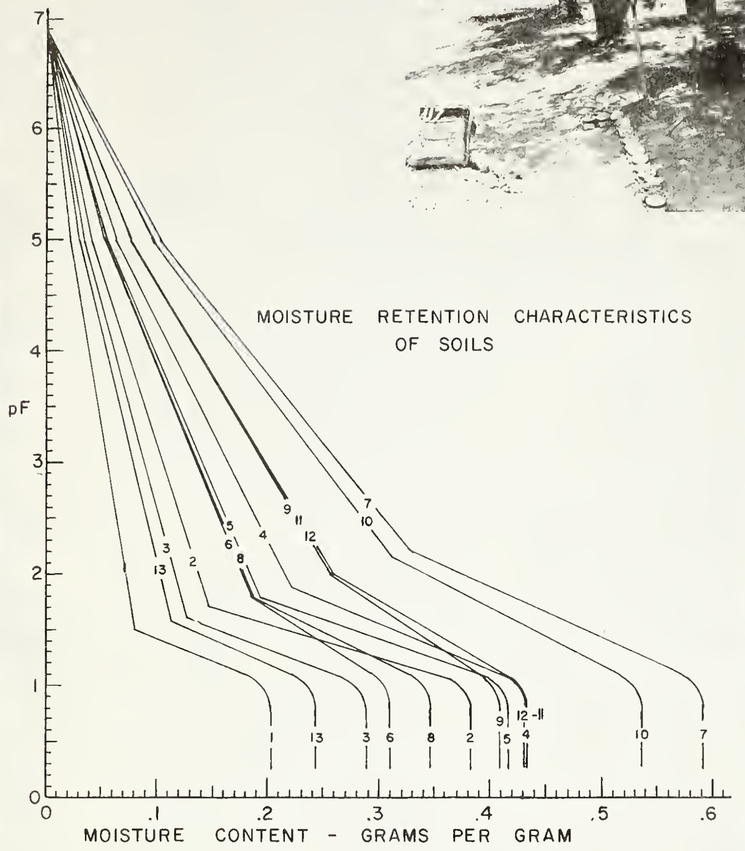


Figure 7

Locations of sampling sites and vegetation types are shown an vegetation map, plate

3 = That portion of the soil profile that normally receives moisture in the vapor phase. A zone of minimal moisture change. Many coincide with the B-2 horizon.

4 = That portion of the soil profile with no evidence of live roots. This usually represents the top of the C horizon.

DPTH = Sampling depth in centimeters. The depth reported is the depth in centimeters to the bottom of the sample.

SM = Soil Moisture or moisture content of the sample in grams of water per gram of dry soil.

VOL WT = Bulk density or apparent volume weight in grams per cubic centimeter. Computed as the dry weight of the soil sample in grams divided by the product of the mean cross-sectional area of the augered hole and the sampling depth increment.

VOL(AVE) = Average bulk density or average apparent volume - weight in grams per cubic centimeter, computed as a moving average. Each figure is the average of three consecutive figures in the preceding column. This computing technique reduces the variability introduced when the auger does not retain the same volume of soil even though the depth to which it is driven is precisely controlled.

FVR = Field Void Ratio - the ratio of the volume of voids to the volume of solids. Computed from the average bulk density by assuming that the density of the solids is 2.65 grams per cubic centimeter, The formula is: $FVR = d_s/d_B - 1$ where d_s = specific gravity of soil particles and d_B = volume weight or bulk density of the soil in situ (Krynine, 1947, p. 45).

VMC = Voids Moisture Capacity - the weight of water in grams that would fill the voids in a unit volume (1 cc) of soil if the soil mass were confined so that the field bulk density is maintained. Computed as: VMC = FVR/2.65 (Krynine, 1947, p. 32).

SMC = Saturation Moisture Capacity. The maximum moisture that a sample will absorb under free-swell disturbed conditions - the moisture content at ultimate hydration. Richards et al., (1954), method 2 or ASTM (1958) Designation D 426-39.

TVR = Void ratio for completely saturated sample computed as 2.65 SMC (Krynine, 1947, p. 32).

G/cc = Total density of saturated paste. Determined by weighing 100 cubic centimeters of saturated paste after tapping the container on a solid surface to remove the larger air bubbles.

SVR = Saturated Void Ratio. Void ratio of saturated paste computed from SMC and total density of saturated paste. This void ratio exceeds TVR by the volume of minute bubbles of air retained in the paste.

pF = The moisture retention force existing in the soil at the time of sampling. Reported is the logarithm of the height of a column of water supported by an equivalent force. pF is measured using the method of McQueen and Miller (1968). This is usually designated as lower case "p" and upper case "F" but the computer does not print lower case letters.

AMC = Adsorbed Moisture Capacity. This represents the moisture content in grams required to satisfy all of the molecular adsorptive forces exerted by a gram of soil particles. Computed as AMC = -6.25 SM/(pF-6.25). This value is the intercept of the adsorbed segment of the moisture characteristic with the X (or zero pF) axis.

CMC = Capillary Moisture Capacity. Computed as SMC-AMC. Where this value is negative, it means that the soil moisture characteristic probably can have no capillary segment because the pores are too small.

LS = Linear Shrinkage. Ratio of the change in diameter of a cylindrical pat of saturated paste during desiccation to the original diameter of the saturated pat.

EC = Electrical Conductivity of Saturated Paste. Richards et al. (1954), method 5 except that a 2-pring stainless steel probe is used in place of the Bureau of Soils electrode cup.

PH = the negative logarithm of the hydrogen ion concentration in the saturated paste. Richards et al. (1954), method 21a.

ROOTS = Relative Concentration of Roots. The material retained on a 60-mesh sieve in a wet sieving process was examined and the relative concentration within the profile was estimated. The concentration of roots in the second sample (10 to 20 cm) was given a value of 10 and the other samples were given relative numbers.

ET = Erosion Time (minutes). Time in minutes required to erode the sample after it has been saturated, puddled, placed in a cylindrical container, allowed to air dry, removed from its container, and subjected to an erosive force that simulates a flowing stream with a velocity of 0.58 meter per second measured about 2 cm from the eroding surface.

TRAN = the ratio of transportable to total weight of a 60-mesh (0.25 mm) sieve has been arbitrarily chosen to define the boundary between suspended and bedload material. Those particles smaller than 0.25 mm can be suspended in a moderately turbulent stream. Particles larger than 0.25 mm will usually be bedload.

EK = Erodibility Constant. Computed as the reciprocal of the logarithm of the erosion time. EK = $1/\log_{10}$ET. This relationship is discontinuous at ET = 1 and because short erosion times are difficult

to measure accurately: for samples where ET approached one minute, a value of two minutes was arbitrarily assigned. Also, when a sample had not disintegrated after 24 hours in the erosion test device, it was removed and arbitrarily assigned a time of 24 hours.

Note: Ek is similar in form to the K value defined by Wischmeier et al. (1969), for use in the universal soil-loss equation. However, it should not be considered as a replacement or duplication because it is derived from erosion tests instead of grain size data. Parallel tests have not been conducted to define the relationships between EK and K.

IR = Infiltration Rate. Computed from the dimensions of the saturated soil pat and the erosion time by assuming that when erosion is complete sufficient water has entered the pat to completely saturate it. When an erosion pat is reinforced with roots or gravel particles in a clay matrix, its ET may be extended and the computed IR may be too small. IR, as reported, should be considered as a minimum infiltration rate in cubic centimeters per square centimeter per hour.

4. Discussion

An objective of this study was to define the hydrologic characteristics of soils associated with vegetation types existing on sites proposed for surface mining of coal. Many hydrologic properties of soils are not constant but can change one or two orders of magnitude under natural conditions. Greater changes can be expected during the disturbance of mining operations.

One property of a soil that will not change appreciably is its specific surface. Hydrologic characteristics that are functions of specific surface can be defined for individual soil samples or for mixtures of soils. The adsorbed film segment of the moisture retention characteristic of a soil is a direct function of the specific surface and can be defined by a single parameter AMC. Evaporation and transpiration can be estimated from the soil moisture characteristics for the soil horizons and a knowledge of the growth patterns and moisture requirements of the plants.

Any hydrologic characteristic that is dependent on the geometry of the pore space will be changed by the disturbance of surface mining. If these characteristics are to be defined, they must be defined in terms of the porosity that will exist or some parameter related to the porosity. The nomograph shown on Figure 8 is provided to assist in making estimates of porosity and related functions. This nomograph assumes a two-phase system of soil particles and water. Where three

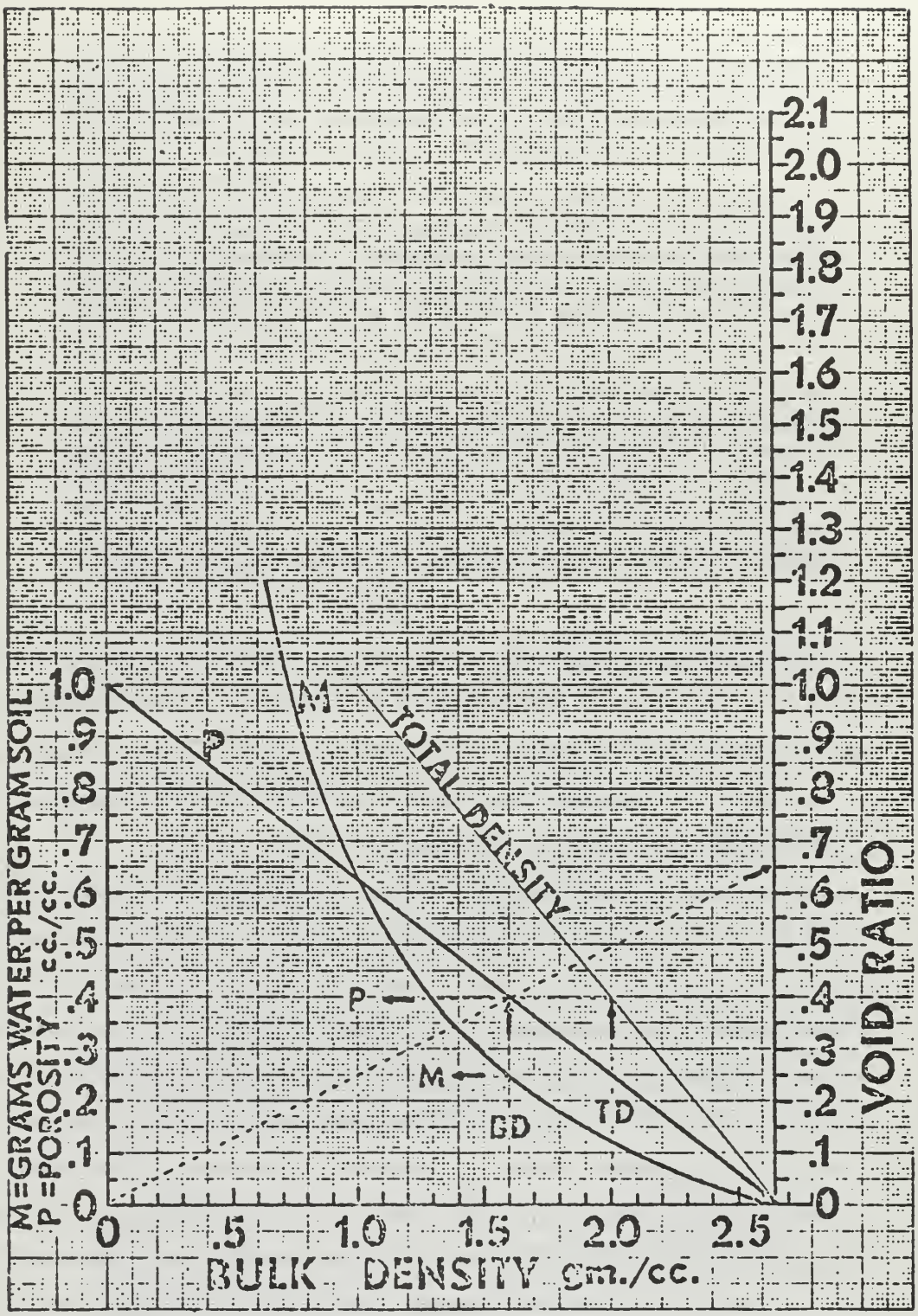


Figure 8 .--Nomograph for conversion between bulk densities, total densities, porosities, saturated moisture contents and void ratios.

phases are present (soil, air, and water), appropriate corrections or adjustments should be made to the data or estimates. For example, when the total density is computed from the moisture content of a saturated paste, it is usually higher than the measured density because of air bubbles included in the paste. A similar source of error is involved in computation of specific gravity of soil particles from shrinkage limit and shrinkage ratio (ASTM [1958] Designation D426-39, paragraph 10).

Void ratios are used to control compaction of soil in engineering practices. The nomograph is useful in conversions between density data, porosities, void ratios, and saturated moisture contents. This nomograph can be constructed for any particle density.

The forces involved in erosion of soils are extremely complex and variable. Prediction of erosion rates from laboratory tests of physical properties of soils has not been successful. It is possible, however, to define relative susceptibility of soils to a given set of erosion forces by controlled tests (McQueen, 1961). For significant results, the erosion forces and the condition of the samples prior to and during the tests should simulate conditions expected in the field.

Three methods for determining soil erodibility have been combined in a laboratory test for defining the susceptibility of these soils to erosion forces: a slaking test suggested by Winterkorn (1973); rotating cylinder methods (described by Masch et al., 1965; Akky and Shen, 1973; Arulanandan et al., 1973); and an erodibility factor (described by Wischmeier and others, 1958, 1959, 1965, 1969, 1971a, 1971b, and 1973) based on measurements of grain size and other physical and chemical properties. This test constitutes a direct determination of the inherent erodibility of individual soil samples.

These data can be averaged and combined to predict the erodibility of the disturbed and mixed soils. Actual erosion and sediment yield from soils will depend more upon the water available to transport the sediments than upon the erodibility (detachability) of the soils. Sand and silt particles are easily detached. Therefore, sandy soils test as highly erodible. However, infiltration may be high enough to absorb all but extreme high intensity storms so erosion and sediment production

on sandy soils are usually low. Clay soils do not test as highly erodible, but runoff is usually excessive so erosion and sediment yields are high.

Vegetation diminishes erosion in three ways: it intercepts raindrop impact; it impedes overland flow; and it binds soil particles together in a root network. The decrease in raindrop impact is proportional to the natural cover (Table 12), but the relationship is species dependent. Impedence of overland flow is influenced by topography, but it is controlled by species and abundance of plants. Grasses are extremely effective, but individual trees may have little effect. The binding effect of roots is included in the erodibility test. Disturbed soils may require additional protection from erosion while vegetation is being reestablished. Overland flow can be controlled by surface treatments such as contour furrowing. Interception of raindrop impact can be provided by mulches placed on the surface, and the binding effect of roots can be simulated by incorporating mulch into the soil.

a. Sample Computations

The data from individual samples presented in this report can be combined and averaged in various ways to predict how the soils will perform when mixed by the mining procedure. Data from sampling sites Nos. 7 and 8 are used here as an example. Similar computations can be made for other materials that may be available.

Assuming that for more efficient mining operations, it would be advantageous to mix the surface soils from sampling sites Nos. 7 and 8, the probable characteristics of the mixture can be computed by averaging the data from individual samples or by using depth-weighted profile averages. The weighted average AMC is computed as: $[(0.506)23 + (0.262)(11)]/34 = 0.427$. The weighted average SMC is 0.511. The soil moisture characteristics for profiles 7 and 8 and the mixed profile are shown in Figure 9. The adsorbed film segments were plotted by using the intercepts (0, 6.25) and (AMC,0) and drawing the lines between pF 2.5 and 5.0. The capillary segment is drawn by using the capillary limit (0, 2.9) and the field capacity value on the adsorbed film segment (FC, 2.5). The mean SMC value is plotted at pF 0.0 and a short vertical segment is drawn which is connected

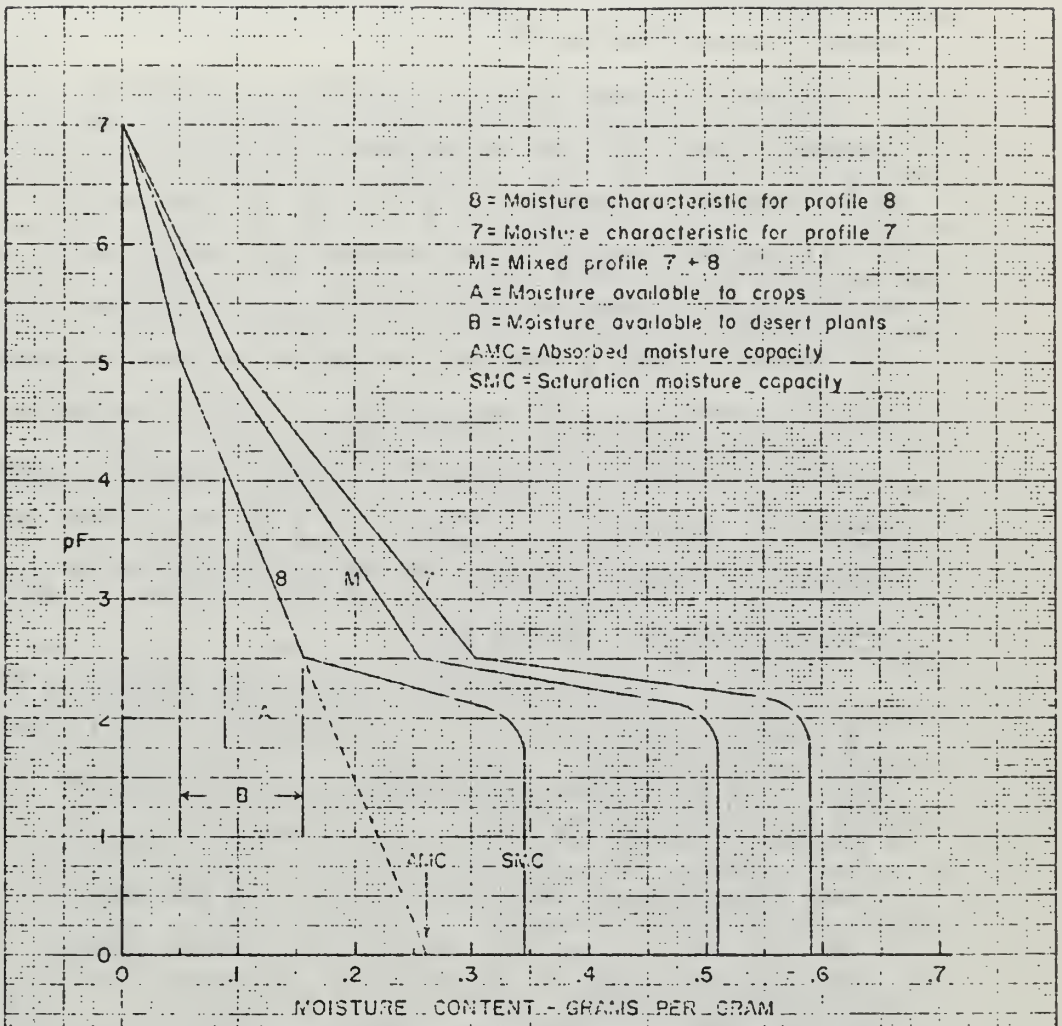


Figure 9.--Soil moisture characteristics for the soils at sites 7 and 8 and the mixture of the two soils.

with the capillary segment. The tightly adsorbed or structured segment is drawn by connecting the top of the adsorbed film segment at pF 5.0 with the zero moisture content value at pF 7.0.

Moisture use between any two stress values can be estimated from the moisture characteristic graph or it can be computed. Where both stress values are included in the adsorbed film segment (2.5 pF 5.0) the moisture use (ΔM) = (AMC/6.25) (pF). The moisture available for use between field capacity and the wilting point for the mixed soil would be (0.427/6.25)(4.2-2.5) = 0.116 gram per gram of soil. The volume or depth of water use per unit of soil depth will depend upon the density or voids ratio of the emplaced soil. If the soil is emplaced at a void ratio of one, the bulk density would be 1.34 (from Figure 8), and the volume of moisture available for use would be (1.34)(0.116) = 0.155 cm of water per cm of soil. Moisture of the capillary segment will only be available for use by plants during and immediately after recharge events.

Analyses of moisture utilization in natural soil profiles have shown that all of the available moisture storage in the 1(A) horizon is utilized during the growing season. In the 2(B) horizon, approximately one half of the available storage capacity is used, and in the 3(B-2) horizon, about one-fifth of the available storage capacity is used. Using the mixed soil from sites 7 and 8 and assuming that horizon depths of 40, 90, and 160 cm will develop, the expected moisture use would be (0.155)(40)+(0.155)(50/2)+ (0.155)(70/5) = 6.2+3.875+2.17 = 12.25 centimeters. Similar estimates can be made for various combinations of soils and horizon depths.

Estimates can be made of the depth of soil that will be recharged by a given storm event. Assume that a surface treatment is applied so that runoff is prevented and that the soil moisture stress or moisture content preceding the storm is known. The moisture content of the wetted portion of the profile will be field capacity, so compute ΔM between antecedent conditions and field capacity. Next multiply ΔM by the bulk density of the soil and divide the total storm amount by this product. Computations for the mixed soil for sites 7 and 8 are as follow:

$$\Delta M = (.427/6.25)(4.37-2.5) = 0.128$$

Using depth-weighted antecedent bulk density of 1.52,

$$(.128)(1.52) = 0.195 \text{ cc/cc}$$

a 6-centimeter storm would wet the profile to a depth of 6/0.195 = 30.8 centimeters.

The storage capacity of the surface treatment required to prevent runoff can be estimated by subtracting the infiltration rate (IR) from expected storm intensities. The average IR for site 7 is 0.474 cm/hr; site 8 is 1.526, the depth-weighted average is 0.81 cm/hr. A 2-hour storm with an average intensity of 3 cm/hr would require (3-0.81)2 = 4.37 cubic centimeters per square centimeter of soil surface.

The geometry of the pore space within soils will be altered by mining operations; and it can be controlled, within limits, by compaction procedures during shaping of the replaced soils. Additional changes in pore geometry will occur during the revegetation process because of wetting and drying or freezing and thawing cycles. Estimates can be made of the probable porosity relationships for mixed profiles by plotting the field void ratios (FVR) against sample depths and sketching an average curve (see Figure 10). This method is suggested because porosity is influenced more by position in the soil profile than by soil physical properties.

A relationship between plant stress, as measured in a pressure chamber, and soil moisture stress is shown in Figure 11. The data from two sites were excluded from the regression because the plants may have had access to ground water. These results should be considered as tentative and subject to revision because of the narrow range of plant stresses measured (pF 4.3 to 4.7).

5. Summary and Inferences from the Data

Selected parameters are summarized by soil horizon and by profiles and presented as averages in Table 12. On the basis of these data, some conclusions and suggestions can be made.

1. Erosion is an obvious problem in the study area and the data indicate that these soils should be protected by surface treatments such as contour furrowing. Soils with EK values less than 0.4 are not considered as highly erodible soils. EK values greater than 0.5 are erodible soils. Infiltration rates are high enough

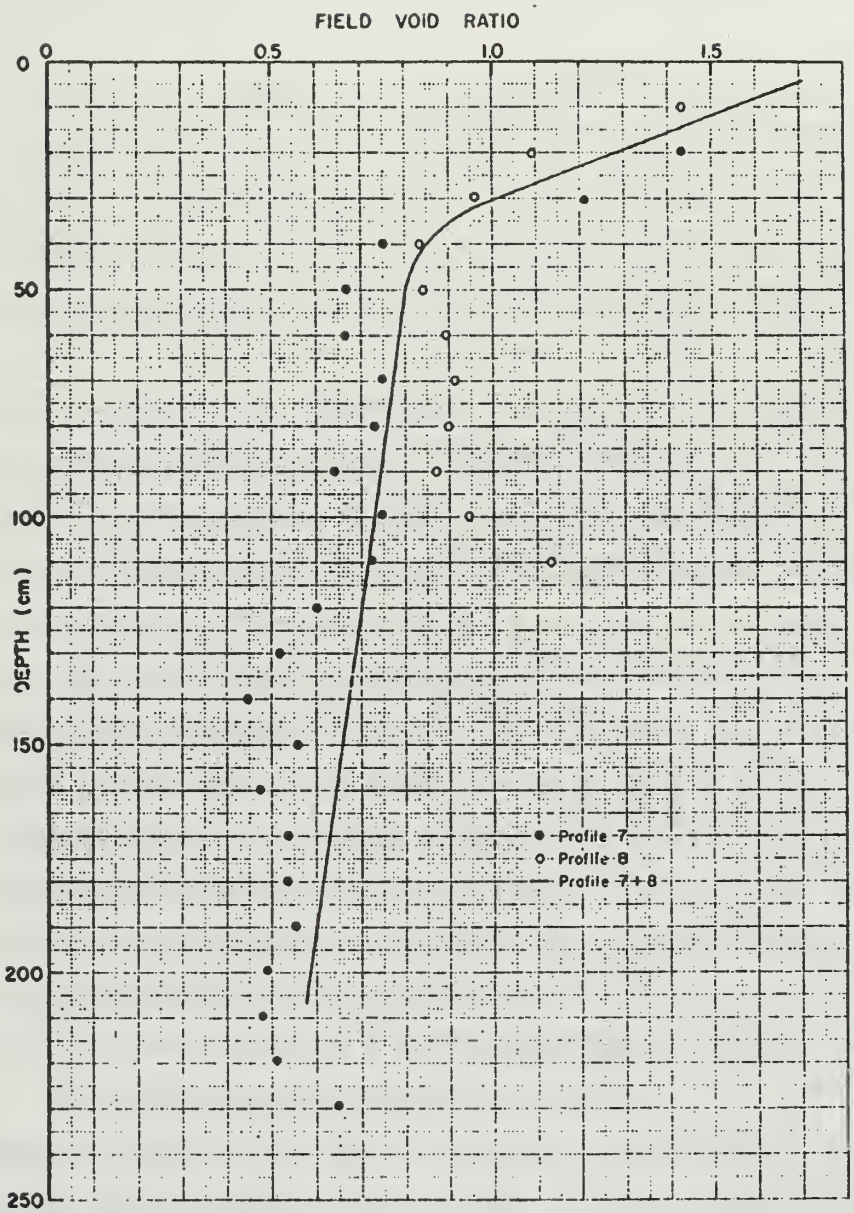
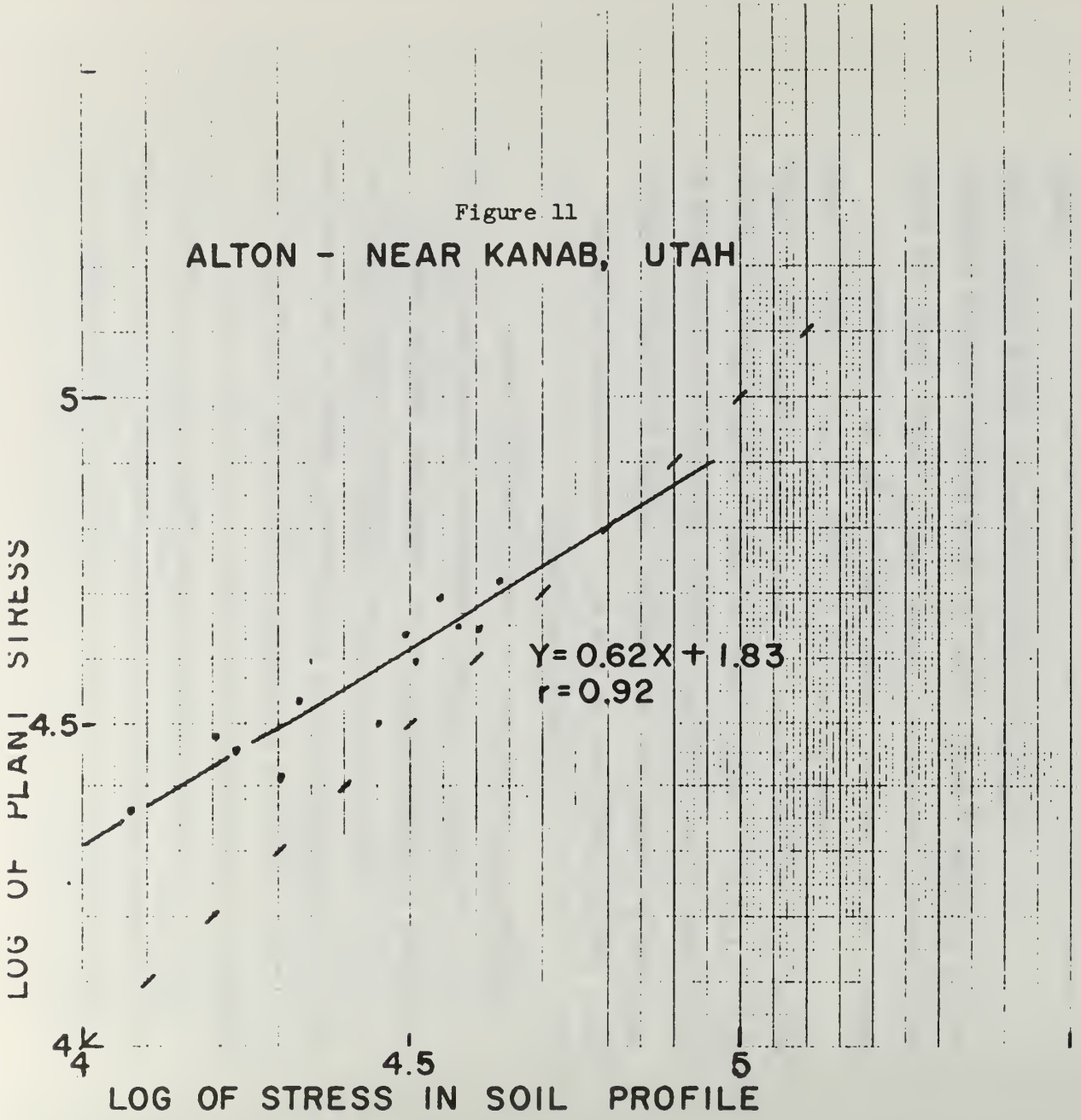


Figure 10.--Chart showing the variation in void ratio with depth at sites 7 and 8 and the probable void ratio-depth curve for the mixed soils after reclamation.

Figure 11

ALTON - NEAR KANAB, UTAH



to limit erosion damage from low intensity storms, but high intensity storms are common in this area. Compaction of these soils would decrease infiltration rates and increase runoff, which would result in increased erosion.

2. The soils of this area have a wide range of moisture-retention capabilities that do not correlate with the type of vegetation or the density of cover. Arid land species may be required for revegetation because other species may require more frequent recharge than prevailing climate patterns provide.

3. Saline problems may develop in the soils from sites 5, 7, and 10; but salts in the surface soils are not generally considered a problem.

6. General Recommendations for Land Surface and Vegetation Reclamation Treatments

Because of the erosive nature of the area, the final shape of the land should be slightly undulating to minimize long flows and concentration of runoff. The soil surface should be mechanically treated by a machine such as the Arcadia Model B contour furrower (Branson, 1966) or gouger (Hodder, et al., 1971). As an additional erosion-control measure, straw at a rate of about two tons per acre should be applied to the soil surface at the time of seeding.

It is anticipated that the area will continue to be used for both domestic animals and wildlife following mining activities. For this reason, a variety of both herbaceous and woody species should be seeded following shaping of the land surface. Species suitable for seeding include the following:

Grasses:

Fairway crested wheatgrass	*(Agropyron cristatum)*
Standard crested wheatgrass	*(Agropyron desertorum)*
Western wheatgrass	*(Agropyron smithii)*
Bluebunch wheatgrass	*(Agropyron spicatum)*
Intermediate wheatgrass	*(Agropyron intermedium)*
Pubescent wheatgrass	*(Agropyron tricophorum)*
Indian ricegrass	*(Oryzopsis hymenoides)*
Russian wildrye	*(Elymus junceus)*
Bottlebrush squirreltail	*(Sitanion hystrix)*

Forbs:

Alfalfa (Rambler, Nomad, or Ladah)	*(Medicago sativa)*

Chickpea milkvetch	*(Astragalus falcatus)*
Utah sweetvetch	*(Hedysarum boreale utahensia)*
Yellow sweetclover	*(Meliloters officinale)*
Arrowleaf balsamroot	*(Bolsamorhiza sagittatus)*
Small burnet	*(Sanguisorba minor)*
Sicklepod milkvetch	*(Astragalus cicer)*

Shrubs:

Antelope bitterbrush	*(Purshia tridentata)*
Fourwing salt-bush	*(Atriplex canescens)*
Clifforse	*(Cowania mexicana standburiana)*
Utah serviceferry	*(Amalanchier utahencia utahemis)*
Birchleaf mountainmahogony	*(Cercocarpus montanus montanus)*
Curlleaf mountainmahogony	*(Cercocarpus ledifolius ledifolius)*
Woods rose	*(Rosa woodsii ultramontana)*
Golden current	*(Ribes aurea)*
Winterfat	*(Eurotia lanata)*

About 20 pounds of seed mixture per acre should be used if seed is broadcast and 12 pounds, if drilled.

The present nearly pure stand of pinyon and juniper provides very little forage for wildlife or livestock. Although it is expected that over a period of time pinyon and juniper will reoccupy the area, it should be possible to greatly improve the habitat for large herbivores.

D. Geology

1. Geologic Data

a. Regional Geology

The study area lies in the west margin of the Kaiparowits Plateau which is in the west border of the Colorado Plateau Province. The Colorado Plateau covers about one-half of the State of Utah; the Kaiparowits Plateau is in southcentral Utah. The Kaiparowits region is characterized by gentle sloping plateaus and even-crested escarpments interrupted by sharp monoclinal flexures that trend northerly. In places, the gentle inclined plateaus are subdivided by sharp monoclinal structures into large gentle tilted blocks.

Three northerly trending regional monoclines traverse the Kaiparowits Region of south central Utah. From west to east, they are the East Kaibab, Escalante, and Waterpocket. Sedimentary formations are folded down to the east over these monoclines. Formations in the western margin of Kaiparowits Region and the study

area are also broken into blocks by northwest trending faults. Typically, strata are downthrown on the west and fault escarpments are eroded in slopes similar to the monoclinal slopes previously mentioned. Displacement on these faults is considerably less than displacement on monoclines being generally less than 100 feet as compared to several hundred feet in monoclines.

The study area is bounded on the east by the Paunsaugunt Fault and on the west by the Sevier Fault. Both trend northeast and are regional in length and displacement. Strata on the west are downthrown and exceed 1,000 feet displacement. The northwest trend of local faults in the study area is divergent to the northeast trend of the above-mentioned regional faults. The relationship between local and regional structures is not fully understood.

b. Site Geology

Sedimentary rocks of Cretaceous Age are exposed over much of the study area. These rocks belong to the Tropic shale and underlying Dakota sandstone. The formations dip northerly about two to four degrees. Outcrops are deeply weathered, and bedding plane attitudes are obscure. The Cretaceous strata are broken by five faults that trend northwesterly. No folding was observed. Large areas are covered by Quaternary surficial deposits of sand, gravel, and cobbles. Structural and lithologic characteristics, drill holes, test pit, and test trench locations are shown on Drawing 1224-OA-300-1. Structural displacement ranges from 10 feet in the fault located 750 feet west of DH-103 to a maximum displacement of 100 feet in the fault along Skutumpah Creek located about 1,100 feet east of DH-101. Four of the five faults indicate that the fault blocks are downthrown on the west side. The remaining fault, located about 250 feet east of DH-104, shows the downthrown block to be on the east side with about 30 feet displacement. Two of the faults are along Thompson Creek and lie east of DH-105, about 750 and 1,325 feet, respectively. These faults indicate about 30 and 35 feet displacement, respectively. A cross section through the drill holes may be seen on Drawing 1224-OA-300-5.

The Tropic shale, shown by symbol Kt on the geologic map, is a marine deposit that forms extensive outcrops over the northern two-thirds of the study

EXPLANATION

QUATERNARY - ALLUVIUM: Principally stream-laid deposits of silt, sand and gravel, that includes undifferentieted slopewash deposits.

QUATERNARY- LANDSLIDE AND COLLUVIUM DEPOSITS: Includes slumps, slopewash end rockfalls undifferentieted. In places, deposits ere contemporeneous with alluvium.

QUATERNARY - PEDIMENT GRAVEL: Older stream-laid and slopewash deposits of boulders, cobbles, grevel and sand. Deposited principelly on the nonresistent Tropic Shale Formation and on surfaces above most of the present drainage.

CRETACEOUS - TROPIC FORMATION: Shale, silty to cleyey thet is very weethered in top 10 to 15 feet. Some thin beds of bentonite and limestone concretions neer base. The topmost is medium brown gray but is blue gray to dark grey in the lower part. The Tropic is reported 650 to 700 feet thick.

CRETACEOUS - DAKOTA FORMATION: Sandstone with interbeds of mudstone, claystone and siltstone Two prominent coal beds merking the top and basal contacts with scattered interbeds of coal and carbon trash. Fossils ere common near the top. The base is unconformable end in places merked with lenses of pebble conglomerate. The Dekota is reported about 200 feet thick.

Coal bed: long deshed where approximately located; short deshed where inferred

Burned coal bed: long dashed where approximately located; short dashed where inferred

100 Projected 100 foot coal highwall

200 Projected 200 foot coal highwall

Coal bloom: black earthy coal on surface

Coal OC: Coal out crop

12° Strike and dip of beds

D U Fault: long dash where approximately located; short dashed where inferred or concealed

Core drill hole

DH 103 Test pit; dug with backhoe

TP7 Test trench; dug with D8-bulldozer

TT102

NOTE: Coordinate base is taken from Utah International Inc. grid system.
Sources of information: Geologic data were taken in part from Utah Internationel Inc. field map end from U.S.G.S. Map MF-521 by H.D. Goode-1973.

R. 5 W. R. 4 1/2 W., S.L.M. R. 4 1/2 W. R. 4 W.

T. 40 S.

E. 1,785,000 E. 1,790,000 E. 1,792,500 E. 1,795,000 E. 1,797,500 E. 1,800,000 E. 1,802,500 E. 1,805,000 E. 1,807,500 E. 1,810,500

N. 337,500 N. 335,000 N. 332,500 N. 330,000 N. 327,500 N. 325,000 N. 322,500

1000 0 1000 2000 3000 4000
SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
EMRIA PROJECT
UTAH

ALTON COAL FIELD

GEOLOGY

GEOLOGY D.L. BRANSTETTER SUBMITTED
DRAFTED R.C. Sorby Jr. RECOMMENDED
CHECKED APPROVED

BOULDER CITY, NEVADA JAN. 27, 1975 | 1224-0A-300-1

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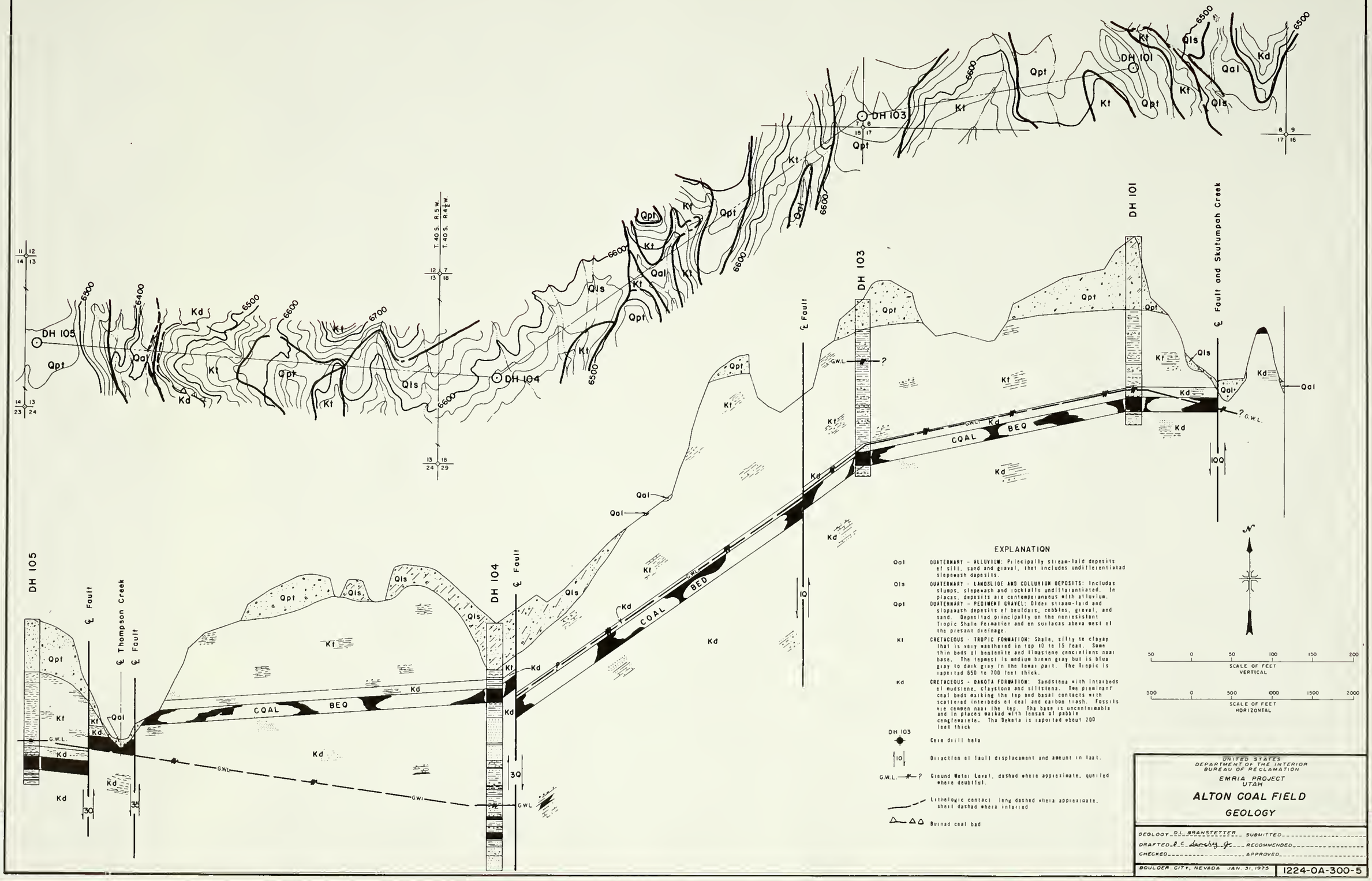

EXPLANATION

Qal	QUATERNARY - ALLUVIUM: Principally stream-laid deposits of silt, sand and gravel, that includes undifferentiated sheetwash deposits.
Qls	QUATERNARY - LANDSLIDE AND COLLUVIUM DEPOSITS: Includes slumps, sheetwash and rockfalls undifferentiated. In places, deposits are contemporaneous with alluvium.
Qpt	QUATERNARY - PEDIMENT GRAVEL: Older stream-laid and slopewash deposits of boulders, cobbles, gravel, and sand. Deposited principally on the nonresistant Tropic Shale Formation and on surfaces above west of the present drainage.
Kt	CRETACEOUS - TROPIC FORMATION: Shale, silty to clayey that is very weathered in top 10 to 15 feet. Some thin beds of bentonite and limestone concretions near base. The topmost is medium brown gray but is blue gray to dark gray in the lower part. The Tropic is reported 650 to 700 feet thick.
Kd	CRETACEOUS - DAKOTA FORMATION: Sandstone with interbeds of mudstone, claystone and siltstone. The preminant coal beds marking the top and basal contacts with scattered interbeds of coal and carbon trash. Fossils are common near the top. The base is uncomformable and in places marked with lenses of pebble conglomerate. The Dakota is reported about 200 feet thick

DH 103 — Core drill hole

10 — Direction of fault displacement and amount in feet.

G.W.L. — ? — Ground Water Level, dashed where approximate, queried where doubtful.

Lithologic contact - long dashed where approximate, short dashed where inferred

Buried coal bed

SCALE OF FEET VERTICAL: 50 0 50 100 150 200

SCALE OF FEET HORIZONTAL: 500 0 500 1000 1500 2000

UNITED STATES
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BUREAU OF RECLAMATION

EMRIA PROJECT
UTAH

ALTON COAL FIELD

GEOLOGY

GEOLOGY D.L. BRANSTETTER SUBMITTED

DRAFTED R.C. Darchy Jr. RECOMMENDED

CHECKED APPROVED

BOULDER CITY, NEVADA JAN. 31, 1975

1224-0A-300-5

area. The rocks are eroded into a variety of topographic forms that range from high elevations of substantial relief to gentle undulating hills to narrow entrenched valleys. The total thickness of the formation is reported to be 650 to 700 feet. It is composed predominantly of silt and clay shale that is blue-gray in the lower part to brownish-gray in the upper part. Outcrops show the topmost part of the shale consists of interbeds of fine-grained sandstone and siltstone. Logs from drill holes show the lower portion to contain lenses of bentonitic clay, fossiliferous beds, and a pronounced bed of concretionary limestone about two feet thick that consistently are about 25 feet above the Dakota sandstone contact.

For convenience in reporting, the first sandstone or mudstone near the base of the Tropic shale is referred to as the top of the Dakota sandstone, designated by Kd on the geologic map. This contact is conformable but is questioned by some authors. The first sandstone or mudstone is commonly about 10 feet above the thick coalbed near the top of the Dakota. The formation is mostly of continential deposition and consists of alternating beds of sandstone and mudstone with a prominent coalbed near the top (about 16 feet thick) and near the base (about 9 feet thick) and thinner coalbeds scattered in between. There are a few claystone and bentonite beds that are fossiliferous in places near the upper section, and conglomerate beds are found near the base. Sandstone lenses will grade laterally into mudstone and claystone. Exposures of the upper section are characterized by cliff forming sandstone up to 15 feet high. Total thickness of the formation is reported to be about 200 feet thick (1) in the study area. The base of the Dakota is marked by an erosional unconformity that truncates either the Entrada sandstone or Winsor formations in this area.

Surficial deposits of Quarternary Age are alluvium (Qal) along the streambeds; as slopewash and colluvium (Qls) along the mountain slopes of high relief; and as older stream-laid and slopewash pediment deposits (Qpt) that cap the elevations above most of the present drainage system. The thickest deposit of 81 feet was encountered at DH-101. These deposits may slightly thicken to the north of the drill hole. They are classified as poorly stratified boulders, cobbles, gravel, and sand deposited largely on the nonresistant Tropic shale. The coarser materials are

principally subangular limestone and sandstone fragments in a finer-grained matrix of silty sand. Caliche cementation is common to a depth of 15 feet.

The alluvial deposits along the streambeds consist of silt, sand, and gravel. Locally, slopewash deposits of boulders, cobbles, and occasional lenses of clay are present. These stream-laid deposits are projected to a depth of 35 feet in Skutumpah Creek, but 10 to 15 feet deep in most of the study area washes.

The materials mapped as Qls are deposits of slopewash and colluvium that are undifferentiated on the map. They consist of limestone and sandstone boulders, cobbles, and gravel along the steeper slopes that are largely derived from the older pediment deposits. Along the more gentle slopes, the materials are more commonly silty and clayey sand derived from the Tropic shale. These deposits were penetrated in DH-104 for a depth of 59 feet, and this thickness is expected to be about maximum in the study area.

2. Geologic Investigations

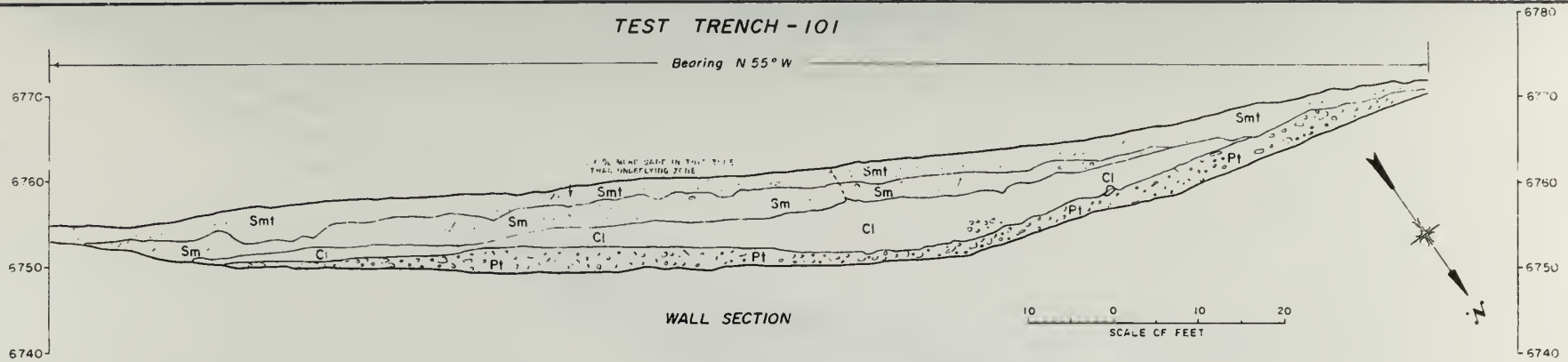
a. Introduction

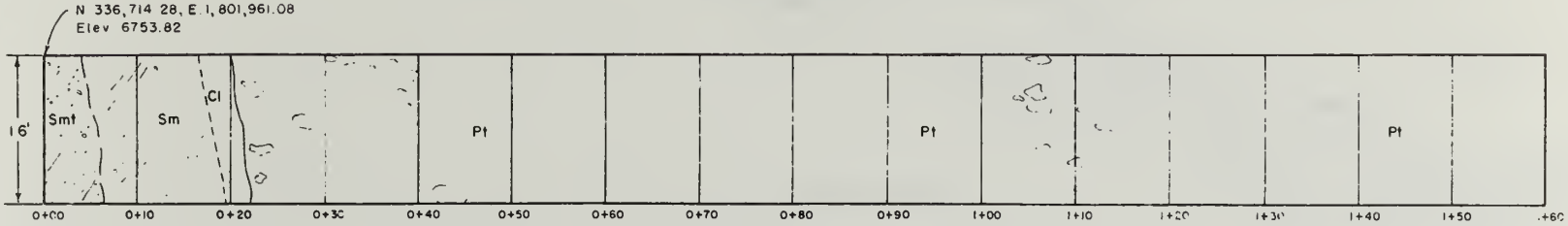
During the period from mid-July to mid-September 1975, geologic field investigations were made in the Alton Coal Field area. Four core holes were drilled; three test trenches dug; 13 test pits dug; and the surface geology mapped.

b. Core Drilling

Four core drill holes, DH-101, DH-103, DH-104, and DH-105 were spaced at about equal distances across the study area (see Drawing No. 1224-OA-300-1 for locations and geologic logs of the drill holes). Drill Hole 102 was not drilled. Each hole penetrated the upper coalbed in the top of the Dakota sandstone. Drill Hole 104 penetrated both the top and lower coalbeds to determine the lithology and thickness of the Dakota. The remaining holes were so spaced to determine depths to the top coalbed, to determine the overburden lithology, and to confirm and correlate mapped structural features found on the surface. Core recovery in formation rock and the upper coalbed averaged 88.5 percent. An attempt was made to core the surficial sand and gravel material in DH-101 with poor recovery. In the remaining holes, a rock bit was used in the sand and gravel and only wash bore samples were recovered for logging purposes. In the formation rock, waxed core samples were taken for testing (see logs for selected intervals).

TEST TRENCH - 101





FLOOR PLAN

EXPLANATION

Material contact gradational where dashed

Silt, sand, gravel, cobbles and boulders.

Smt: Silty Sand; About 70 percent poorly graded fine sand and 30 percent slight to nonplastic fines. Material is loose, blocky and ravels from trench wall. Contains many roots and trace of humus. The silty sand is more limy with a trace of gravel from Sta. 0+92 to Sta. 1+60. Dark brown color. Topsoil.

Sm: Silty Sand; About 60 percent poorly graded fine to very fine sand and 40 percent non-plastic fines. Trace of subangular limestone gravel. Material is firm and dense. Mapped wall stands vertical for 5 feet. Becomes slightly limy near base contact and very limy from Sta. 0+92 to 1+60. Light reddish-brown color. Subsoil.

Cl: Leon Clay; About 70 percent medium plastic fines and 30 percent fine to very fine sand. Trace of subangular limestone gravel and cobbles. Several limy streaks and nodules. Material is firm and very dense. Stands in a 7 foot vertical wall. Rusty brown color. Alluvium.

Pt: Pediment Gravel; About 60 percent subangular to subrounded well graded limestone gravel in a matrix of 30 percent fine sand with few medium to coarse sizes and 10 percent non to low plastic fines. Materials contain about 10 percent (by volume) of limestone and sandstone cobbles and boulders, maximum size 3 1/2 feet. Coarse material is caliche coated and fine materials are very limy. From Sta 1+30 to 1+60 material is more limy and contains chalky gravel. Pt ravels along a 2 foot vertical wall. Mottled light brown gray and red brown. Classified older stream laid and slopewash alluvial deposits.

NOTES

Trench excavated with D-8H (46A) dozer, 4'x12' blade and dual rippers. Weight of dozer 35 tons. Excavation time 9 hours backfill time 7 hours. Mapped wall is vertical and on west side. Area of trench excavation has an angle of repose of about 7° that is moderately covered with juniper & pinon pine trees 25' tall. All materials excavated are believed to be Quaternary - alluvial deposits

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

EMERY PROJECT
UTAH

ALTON COAL FIELD

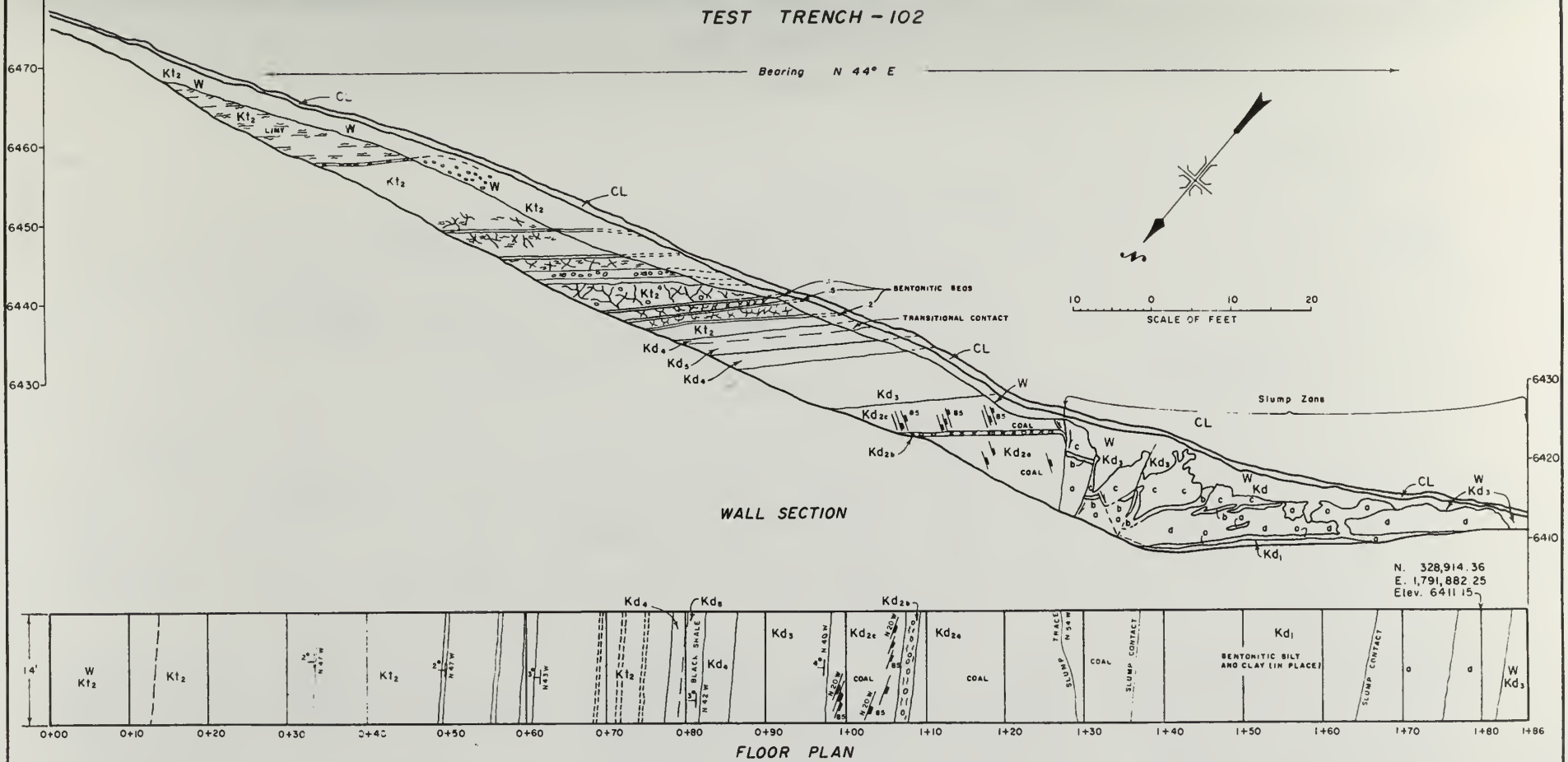
GEOLOGY

GEOLOGIC TEST TRENCH 101

GEOLOGY DL BRANSTETTER	SUBMITTED
DRAFTED DF RUSSELL	RECOMMENDED
CHECKED	APPROVED

BOULDER CITY, NEVADA JAN 27, 1975

1224-0A-300-2



EXPLANATION

N20W 85 Joint strike and dip attitude, designated [illegible] eats in coal beds

Gypsum veinlets range from 1/8" to 3/4

Bentonitic, thin beds, streaks and nodules

Lithologic contact, gradational where dashed

Direction of slump block movement

4° N20W Bedding plane, strike and dip attitude

Concretions fossiliferous limestoney and [illegible]

Kt Cretaceous Age - Tropic Formation

Kd Cretaceous Age - Dakota Formation

CL Lean Clay; About 80 percent medium to high [illegible] fines 20 percent fine to very fine sand with a [illegible] of subangular sandstone and limestone gravels, cobbles and boulders up to 3 ft in the largest dimension Materials are very limy, slightly humus and dark gray in color loose when dry, very slick when wet Top soil

W: Highly weathered zone with downslope creep [illegible] consolidated, limy, and contains large roots [illegible] material is moderately weathered below this zone

Kt2: Shale and Claystone; gray to light gray [illegible] beds of light gray bentonite; several limestone [illegible] with fossils more common in or near bentonitic [illegible] sandy near base and limonite stained

Kd4: Sandstone, fine to silty, light gray with [illegible] of bentonite, moderately cemented, can crush 1/2 [illegible] ment with pliers, blocky - base contact is [illegible] with underlying black shale that air slakes and is brittle, can crush 1/2" pieces with fingers

Kd5: Black shale; Silty, calcareous, blocky and fissile (lab analysis shows the shale to be 17 percent carbon) several thin laminae (- 1/8 inch) of bentonitic silt; includes random gypsum veinlets and a few rootlets.

Kd3: Sandstone; light gray-tan, thin bedded, silty with carbon trash in thin laminations; interbeds of carbonaceous mudstone, thin bedded with fossils in middle zone (1.6 ft.) limy 2 ft. below black shale contact to lower coal bed These materials are in slump zone from Sta 1+28 to 1+86.

Kd2c: Coal; slightly to moderately weathered; silty parting (1/16 inch) 2.4 ft. below top, many near vertical cleats that strike N15W These materials are designated "C" in slump zone from Sta 1+28 to 1+55.

Kd2b: Mudstone; light brown carbon with yellow silt staining, few gypsum veinlets These materials are designated "b" in slump zone from Sta 1+28 to Sta 1+55

Kd2a: Coal; slightly to moderately weathered, many cleats (0.2' spacing), air slakes easily in a few days exposure, the coal air slaked from wall 2 ft deep; few gypsum veinlets along upper contact. These materials are designated "a" in slump zone from Sta. 1+28 to 1+77

Kd1: Bentonitic silt and clay; yellow to gray tan, carbonaceous in upper zone, blocky can crush 1-inch fragments with pliers These materials are in place and not effected by overlaying slump zone

Kd2d: Sandstone; fine grain, slump material contains carbon trash and coal pockets with fragments of yellow and red silty streaks and lenses. Includes bentonitic streaks and nodules. These materials are designated "d" are totally in the slump zone from Sta. 1+35 to 1+86.

NOTES

Excavated with D-8H (46 A) dozer 4'x12' blade and dual rippers. Weight of dozer 35 tons. Excavation time 9 hours, backfill time 10 hours Mapped wall is vertical and on southside. Area of trench excavation has 25° angle of repose. surface is lightly covered with juniper and pinon pine trees 15' tall.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
EMRIA PROJECT
UTAH

ALTON COAL FIELD

GEOLOGY

GEOLOGIC TEST TRENCH 102

GEOLOGY D.L. BRANSTETTER SUBMITTED

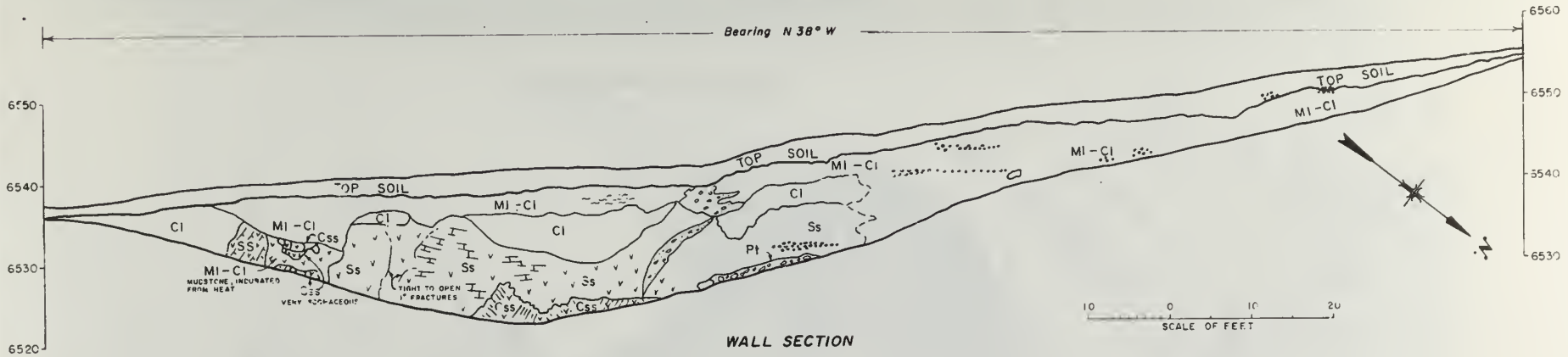
DRAFTED D.P. RUSSELL RECOMMENDED

CHECKED APPROVED

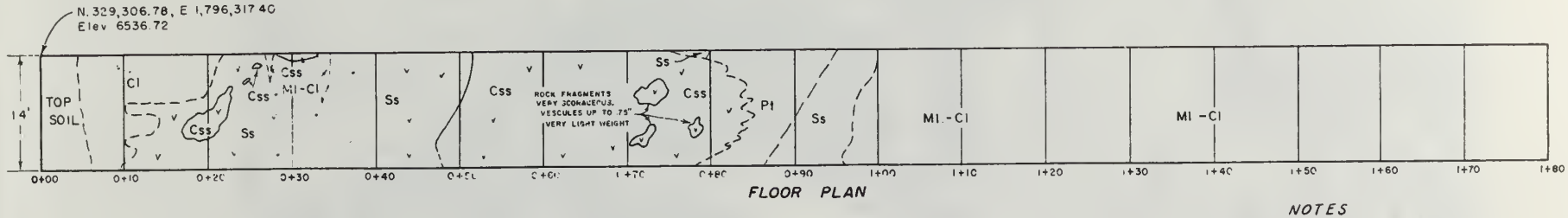
BOULDER CITY, NEVADA JAN. 27, 1975

1224-0A-300-3

TEST TRENCH – 103



WALL SECTION



FLOOR PLAN

EXPLANATION

- Joint, denotes strike and dip
- Bedding planes in limy sandstone
- Material contact gradational where dashed
- Structural planes, bedding joints and fractures
- Limy streaks and nodules
- Indurated from heat (burned coal)
- Sand, Gravel and Cobbles

Top Soil - Leon clay, about 70 percent medium to highly plastic fines, 20 percent fine sand and 10 percent subangular sandstone and limestone gravel lenses. Coarser materials mostly caliche coated. Material is very limy and contains many caliche veinlets and nodules with a trace of humus. Soils are loose, very weathered and contains several roots. Color is dark brown. Classified as top soil derived from the Tropic Formation.

CI: Lean Clay; About 80 percent medium plastic fines, 20 percent fine sand and trace of sandstone gravel. Clay becomes more sandy with depth. Material is limy with caliche nodules and veinlets; firm, blocky and stands vertical in a 7 foot wall. Few rootlets in upper 18 inches. Reddish-brown color. Classified alluvial subsoil, derived from the Tropic Formation.

MI-CI: Leon Sandy Clay; About 60 percent slight to medium plastic fines, 30 percent fine sand and 10 percent subangular sandstone gravel lenses. Materials are limy with caliche streaks and nodules and some carbon fragment (1/2 inch). Firm with blocky structure. Material stands vertical in a 15 foot wall. Contains few rootlets in upper 6 feet. Brown in color. Derived as alluvium from mixtures of Tropic and Dakota Formation.

Ss: Sandstone; poorly graded fine sand mostly metamorphosed into clinkery sandstone from burning coal. Blocky, fragmental and very jointed. Variable hardness, can crush most 1/2-inch fragments with pliers. Texture is sugary and brittle. Material is limy, color will range from red to yellow to maroon. SS will stand in 13 foot wall but will slake from the wall 24-inches deep in places. Source of material is unknown but believed to be indurated alluvium derived from the Dakota Formation.

Css: Clinker Sandstone; fine grain, highly metamorphosed from coal burn. In places are solidified flow zones and vesicular cavities up to 3/4 inch, very light weight. Hard can crush 1/4 to 1/2-inch fragments with pliers. Blocky, porous, ravelly, and very jointed. Fragments break up into cinders from dozer tracks. Color will range from red to purple to black-green and yellow. Material could possibly be in place Dakota Formation or metamorphosed alluvial sand.

Pt: Pediment Gravel; About 60 percent well graded limestone gravel, 20 percent fine sand and 20 percent slight to medium plastic fines. Contains subangular limestone cobbles (15 percent by volume). Materials are limy, with few limy white chalk gravels. Brown in color. Classified as older stream-laid and slopewash alluvial deposits.

NOTES

Trench excavated with D-8H (46A) dozer 4'x12' blade and dual rippers. Weight of dozer 35 tons. Excavation time 15 hours, backfill time 11 hours. Mapped wall is vertical and on west side. Area of trench excavation has an angle of repose of about 11° that is moderately covered with juniper and pinon pine trees 20' tall.

All materials excavated are believed to be Quaternary - alluvial deposits, derived from either Cretaceous-Tropic or Dakota Formation.

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EMRIA PROJECT
UTAH

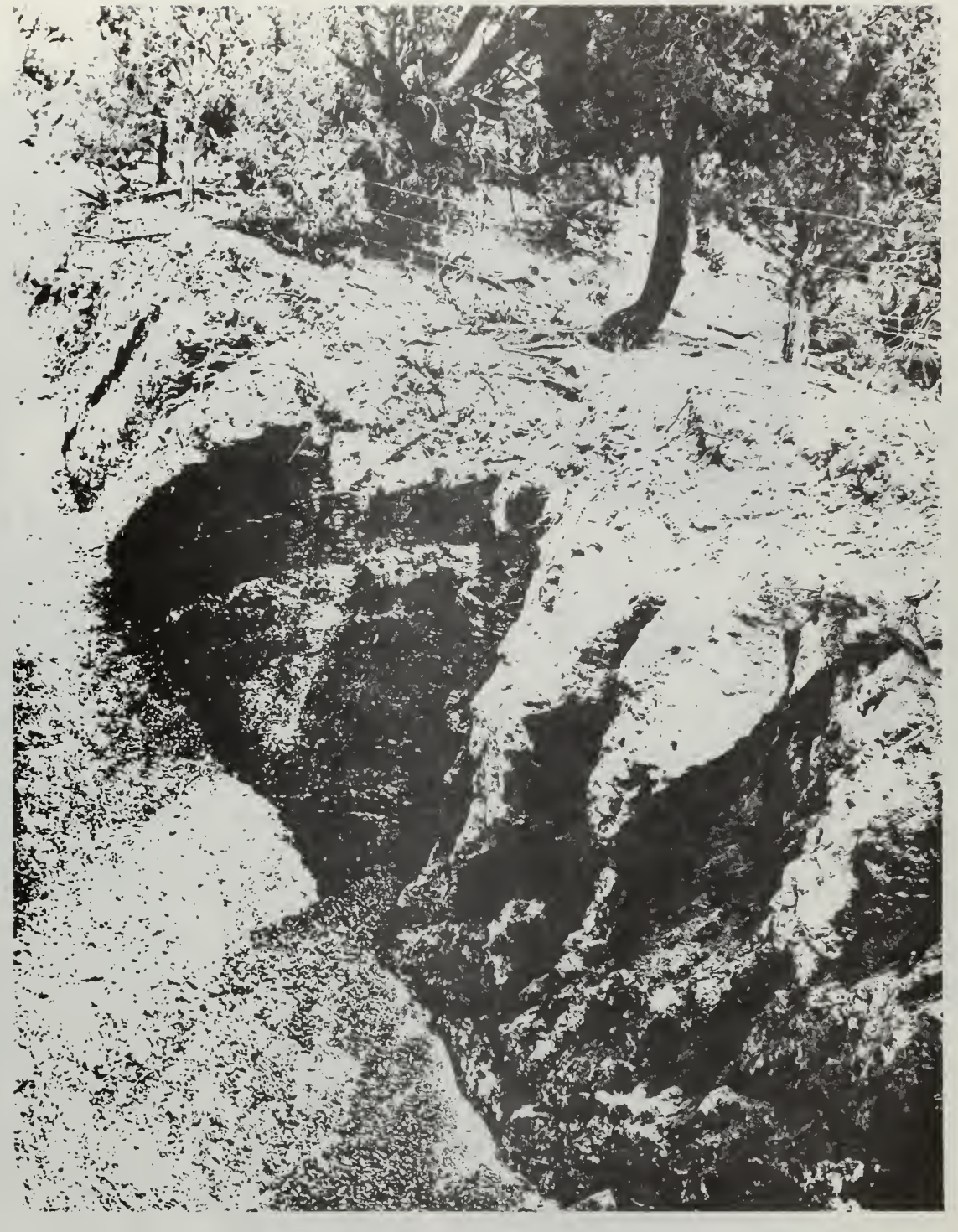
ALTON COAL FIELD

GEOLOGY

GEOLOGIC TEST TRENCH 103

GEOLOGY D.L. BRANSTETTER ..SUBMITTED.....
DRAFTED D.P. RUSSELL .....RECOMMENDED.....
CHECKED.....APPROVED.....

BOULDER CITY, NEVADA JAN 28, 1975 | 1224-0A-300-4



P1224-300-01005 NA Alton Coal Field - Emira Project (BLM)--UT
View of measured 15-foot coal bed in Test Trench 102. Coal beds in foreground are in slump zone. Land Reclamation studies are being conducted for potential coal strip-mining areas. This area is located northeast of Kanab, Utah,
8-28-74 Bureau of Reclamation photo by E. E. Hertzog.

P1224-300-01007 NA Alton Coal Field - Emira Project (BLM)--UT
View of mapped wall in Test Trench 103. Trench was dug to a depth of about 19 feet. Geologists are looking at sandstone charred to clinker from prehistoric coal burn. Land Reclamation studies are being conducted for potential coal strip-mining areas. This area is located northeast of Kanab, Utah.
8-28-74 Bureau of Reclamation photo by E. E. Hertzog

P1224-300-01008 NA Alton Coal Field - Emira Project (BLM)--UT
View of mapped wall in Test Trench 101. Trench was dug with D-8 bulldozer to a depth of about 12 feet. Material is classified as alluvial claycy sand in the wall, and pediment gravel along the trench floor. Land Reclamation studies are being conducted for potential coal strip-mining areas. This area is located northeast of Kanab, Utah.
8-28-74 Bureau of Reclamation photo by E. E. Hertzog

In addition to the geological logs, geophysical logs consisting of natural gamma ray and single point resistance were made in each drill hole. These logs are not included in the report but are available at the Kanab District Office of the Bureau of Land Management in Kanab, Utah. The combination of these two types of logs is an effective tool in coal identification and indication of lithologic contacts. Coalbeds exhibit very low radioactivity in gamma ray logs and single point resistance logs will indicate high resistance.

c. Test Trenches

Three test trenches, TT-101, TT-102, and TT-103 were dug with a D8-H bulldozer (see Drawings 1224-OA-300-2, -3, and -4 for test trench drawings). Photographs P1224-300-01005, -01007, and -01008 are views of each test trench. The trenches were dug to study the excavation properties in various types of material, degree and depth of weathering in these materials, and to measure a lithologic section of the Tropic shale immediately above the prominent coalbed in the upper Dakota sandstone. The trenches were logged, some samples were collected, then backfilled. A permanent 3-strand barbed wire fence was built around each trench to prevent livestock entry. It is planned to seed the backfilled material with native grass seed and monitor its growth for a period of time.

d. Test Pits

Thirteen test trenches were dug with an 18-inch backhoe to a maximum depth of 11.5 feet. Logs of the pits are included in this report. The engineering properties of the materials were logged by the Unified Soils Classification System. Also the origin of the materials was recorded, the degree of sloping land surface, and the surface conditions in the immediate area.

e. Mapping

Geologic field mapping covered secs. 8, 17, and 18 of T. 40 S., R. W4-1/2 and sec. 13, T. 40 S., R. 5 W. The red to pink colored clinker rock from burned coal was useful in mapping the coal outcrop in the upper Dakota sandstone. These burned zones are shown on the geologic map with sawtooth-shaped symbols along the outcrop contact.

a. Burned Coal

Coalbeds have burned along 40 percent of the outcrop in the mapped area leaving clinker beds, collapse breccias, and baked overburden. Many burned areas are best described as clinkered hills and slopes which are frequently covered by brittle pink and red platy chips of baked shale. How far these beds are burned into the outcrop is not known, but reports in other areas (1) state that 100 feet is possible or as long as there is oxygen present.

b. Highwalls

One-hundred- and 200-foot highwalls are projected from the mapped coal outcrop in the study area. The highwalls were computed by utilizing measured formation rock attitudes and the average slope for a given area. The horizontal distance to the highwall (either the 100- or 200-foot) is equal to the height of the highwall in feet divided by the tangent quantity of dip angle plus the tangent of the sloping surface angle. Points were located in areas where extreme changes in topography were noted or in areas where the formation rock attitude changed. These points were then connected to present the highwall contour.

c. Resource

Calculating the coal resource for the upper coalbed in the Dakota sandstone must be made from limited exposures of coal in place and accounting for the volume of burnt-out coal. The coal available is calculated by multiplying the approximate acreage of coal from the outcrop to the 200-foot highwall by the estimated thickness (based on core drilling and limited outcrops). The tonnage averages about 1,770 tons per acre-foot. This coal is classified by others as subbituminous. In burned areas, coal is presumed to be present 100 feet back from the outcrop. Along narrow ridges or where overburden is thin, the coal may be burned a greater distance from the outcrop.

An average thickness of 16 feet of coal is used to compute the tonnage of coal to the 100- and 200-foot highwalls. This average is based on the core from the four drill holes. There are 16,100,000 short tons of coal from the outcrop to the 100-foot highwall, and 11,147,000 short tons of coal from the 100-foot highwall to the 200-foot highwall. This makes a total of 27,247,000 short tons of coal available to a depth of 200 feet within the study site.

4. Ground Water

The ground-water table was reached in each of the four core drill holes except for DH-103. The date and measurements of the water levels are recorded in each of the geologic logs. In DH-103, it is believed the water level reading of 76-foot depth (taken on two succeeding days) is a measurement of drill-water saturated rock. The hole was completed with a cement plug and provides no chance for further measurements. Water level readings in the remaining holes are believed stabilized measurements. These readings were taken from four to nine weeks after the holes were completed. It is believed that the ground-water table is erratic and probably controlled by the lithology and structure in the study area. The expected ground-water table is shown on Drawing 1224-OA-300-5. Over most of the study area, the coal is expected to be saturated at about depths of 120 feet below drainage areas, 180 feet below the ridges, and about 20 to 30 feet below the streambeds in Thompson Creek and Skutumpah Creek. In places, a drainage system would probably have to be installed and maintained during excavation.

5. Engineering Properties

Overburden excavation would be entirely in the described surficial deposits of sand, gravel, and cobbles and in the Tropic shale. The surficial materials are unconsolidated and are classified as common excavation. The caliche content in the top 15 to 20 feet of pediment gravels would offer some resistance. The natural slope for these materials resting on shale ranges from 20:1 in the gentle sloping areas and 3:1 along sloping ridge lines. As observed in the test pits and trenches, when damp, the materials containing a binder stand vertical for 20 feet; pockets without binder spall out of the walls to depths of two feet.

The Tropic shale is thickly bedded, slightly jointed, with blocky structure, but locally fissile. One-half inch fresh shale fragments can be crushed with pliers; damp weathered shale can be molded with your fingers and is sticky when wet. Weathered shale can be expected to depths of 10 to 15 feet and will stand on 1/4:1 cut slope to heights of 15 feet. Fresh shale should stand on vertical cuts for several feet, but will air slake and ravel after a few hours exposure or upon drying. In the mapped area, the shale stands on a natural slope of 2:1.

IV. COAL RESOURCES - Abstract

Abstract

The estimated original identified coal resources of the Alton EMRIA site–an area of about 3.6 square miles–total almost 49 million tons. A larger area that surrounds and includes the Alton EMRIA site proper contains estimated original identified coal resources of almost 309 million tons. Of these estimated resources, almost 27 million tons are in beds more than 10 feet thick which are overlain by less than 200 feet of overburden in the EMRIA site proper. In the larger area around and including the EMRIA site, about 88.5 million tons are in beds more than ten feet thick with less than 200 feet of overburden. All the estimated resources are in the Smirl zone in the upper part of the Dakota formation of Cretaceous Age.

The coal has an apparent rank of subbituminous B, has an average heating value of about 9,560 Btu, an average sulfur content of about 1.0 percent, and an average ash content of 7.2 percent. When compared with the average abundance of elements in the crust of the earth as a whole, only selenium and boron were present in the Alton area coal samples in amounts greater than the average crustal abundance by an order of magnitude. Beryllium, fluorine, nickel, zinc and zirconium are all present in the Alton area samples in amounts that are less than the average crustal abundance by about an order of magnitude.

IV. COAL RESOURCES

IV. COAL RESOURCES

A. Origin

Coal has been defined as "a readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. formed from compaction or induration of variously altered plant remains similar to those of peaty deposits. Differences in the kinds of plant materials (type), in degree of metamorphism (rank), and range of impurity (grade), are characteristics of varieties of coal" (Schopf, 1956). Inherent in the definition is the specification that the coal originated as a mixture of plant remains and inorganic mineral matter that accumulated in a manner similar to that in which modern-day peat deposits are formed. The peat then underwent a long, extremely complex process called "coalification" during which diverse physical and chemical changes occurred as the peat changed to coal, and the coal assumed the characteristics by which members of the series are differentiated from each other. The factors that affect the composition of coals have been summarized by Francis (1961, page 2) as follows:

1. The mode of accumulation and burial of the plant debris forming the deposits.
2. The age of the deposits and their geographical distribution.
3. The structure of the coal-forming plants, particularly details of structure that affect chemical composition or resistance to decay.
4. The chemical composition of the coal-forming debris and its resistance to decay.
5. The nature and intensity of the plant-decaying agencies.
6. The subsequent geological history of the residual products of decay of the plant debris forming the deposits.

For extended discussions of these factors, the reader is referred to such standard works as Moore (1940), Lowry (1945), Tomkeieff (1954), Francis (1961), and Lowry (1963).

B. Classification

Coals can be classified in many ways (Tomkeieff, 1954, page 9; Moore, 1940, page 113; Francis, 1961, page 361), but the classification by rank--that is, by degree

of metamorphism in the progressive series which begins with peat and ends with graphocite (Schopf, 1966)–is the most commonly used system. Classification by type of plant materials is commonly used as a descriptive adjunct to rank classification when sufficient megascopic and microscopic information is available, and classification by type and quantity of impurities (grade) is frequently used when utilization of the coal is being considered. Other categorizations are possible and are commonly employed in discussion of coal resources–such factors as the weight (specific gravity) of the coal, the thickness and areal extent of the individual coalbeds, and the thickness of overburden are generally considered.

1. Rank of Coal

The designation of a coal within the metamorphic series, which begins with peat and ends with graphocite, is dependent upon the temperature and pressure to which the coal has been subjected and the duration of time of subjection. Because coal is largely derived from plant material, coal is mostly composed of carbon, hydrogen, and oxygen, along with smaller quantities of nitrogen, sulfur, and other elements. The increase in rank of coal as it undergoes progressive metamorphism is indicated by changes in the proportions of the major coal constituents–the higher rank coals have more carbon and less hydrogen and oxygen than the lower ranks.

Two standardized forms of coal analyses–the proximate analysis and the ultimate analysis–are generally made though sometimes only the less complicated and less expensive proximate analysis is made. The analyses are described as follows (U.S. Bureau of Mines, 1965, pages 121-122):

> "The proximate analysis of coal involves the determination of four constituents: (1) water, called moisture; (2) mineral impurity, called ash, left when the coal is completely burned; (3) volatile matter, consisting of gases or vapors driven out when coal is heated to certain temperatures; and (4) fixed carbon, the solid or cakelike residue that burns at higher temperatures after volatile matter has been driven off. Ultimate analysis involves the determination of carbon and hydrogen as found in the gaseous products of combustion, the determination of sulfur, nitrogen, and ash in the material as a whole, and the estimation of oxygen by difference."

Most coals are burned to produce heat energy so the heating value of the coal is an important property. The heating value (calorific value) is commonly expressed in British thermal units (Btu) per pound: 1 Btu is the amount of heat

required to raise the temperature of 1 lb of water 1°F (in the metric system, heating value is expressed in kilogram-calories per kilogram). Additional tests are sometimes made, particularly to determine the caking, coking, and other properties, such as tar yield, which affect classification or utilization.

Figure 12 compares in histogram form the heating value, and the moisture, volatile matter, and fixed carbon contents of coals of different ranks.

Various schemes for classifying coals by rank have been proposed and used but the one most commonly employed in the United States is the "Standard specifications for classification of coals by rank," adopted by the American Society for Testing and Materials (1974, Table 13).

The ASTM classification system differentiates coals into classes and groups on the basis of mineral-matter-free fixed carbon or volatile matter, and the heating value supplemented by determination of agglomerating (caking) characteristics. "Coals which in the volatile matter determination produce either an agglomerate button that will support a 500 g weight without pulverizing, or a button showing swelling or cell structure, shall be considered agglomerating from the standpoint of classification (ASTM, 1974, page 56)."

As pointed out by the ASTM (1974, page 55), a standard rank determination cannot be made unless the samples were obtained in accordance with standardized sampling procedures (Snyder, 1950; Schopf, 1960). However, nonstandard samples may be used for comparative purposes through determinations designated as "apparent rank."

All samples listed in Table 14, except D169563, show an apparent rank of subbituminous B. The sample came from weathered coal in test trench 102, and therefore the analysis may not be representative.

Because of the lack of definitive information about the distribution of coals of various groups in the Alton coal field, the coal in the area of this study is considered to be all subbituminous B in rank.

2. Type of Coal

Classification of coals by type–that is, according to the types of plant materials present–takes many forms, such as the "rational analysis" of Francis (1961), or

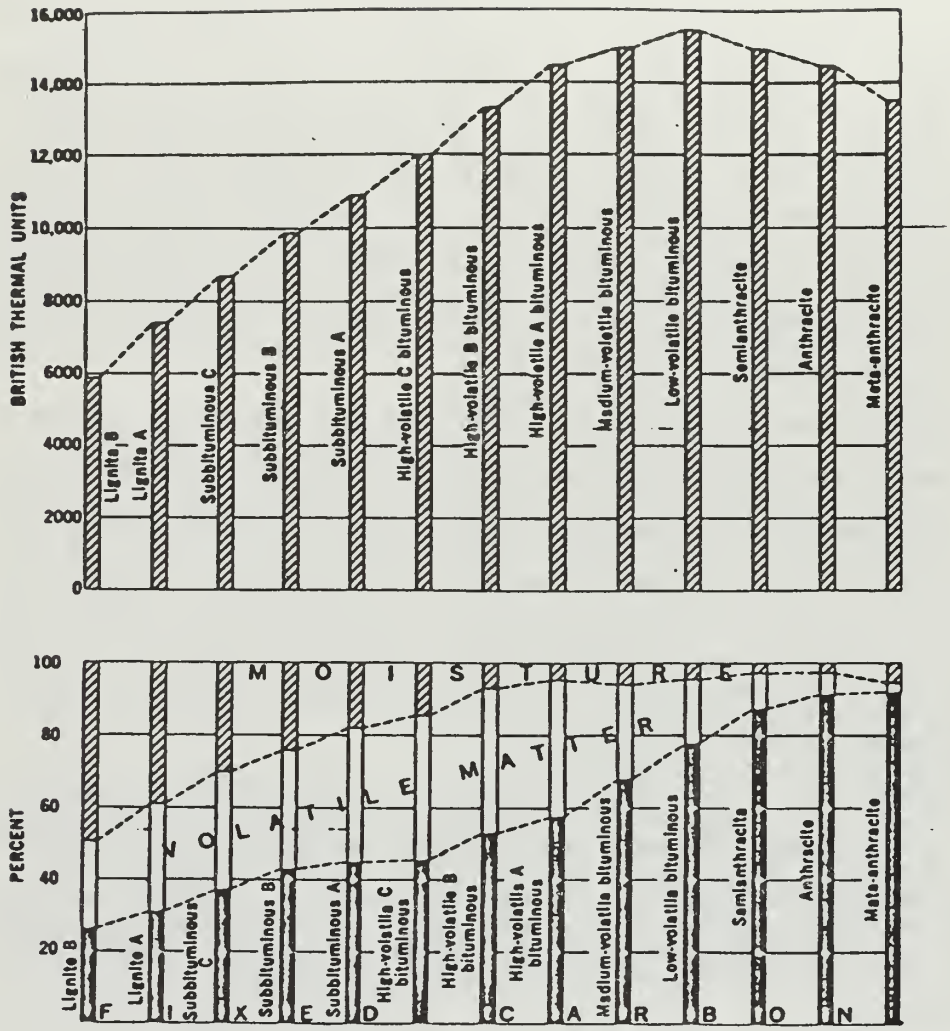


Figure 12.--Comparison on moist, mineral-matter-free basis of heat values and proximate analyses of coal of different ranks.

Table 13 Classification of coals by rank[1]
[American Society for Testing and Materials Standard D388-66 (Reapproved 1972)]

Class	Group	Fixed Carbon Limits, percent (Dry, Mineral-Matter-Free Basis)		Volatile Matter Limits, percent (Dry, Mineral, Matter-Free Basis)		Calorific Value Limits, Btu per pound (Moist,[2] Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	
I. Anthracite	1. Meta-anthracite	98	...	...	2	...	...	nonagglomerating
	2. Anthracite	92	98	2	8	...	...	
	3. Semianthracite[3]	86	92	8	14	...	...	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	...	...	Commonly agglomerating[5]
	2. Medium volatile bituminous coal	69	78	22	31	...	...	
	3. High volatile A bituminous coal	...	69	31	...	14 000[4]	...	
	4. High volatile B bituminous coal	...	...	...	...	13 000[4]	14 000	
	5. High volatile C bituminous coal	...	...	...	...	11 500	13 000	
						10 500	11 500	agglomerating
III. Subbituminous	1. Subbituminous A coal	...	...	...	...	10 500	11 500	nonagglomerating
	2. Subbituminous B coal	...	...	...	...	9 500	10 500	
	3. Subbituminous C coal	...	...	...	...	8 300	9 500	
IV. Lignitic	1. Lignite A	...	...	...	...	6 300	8 300	
	2. Lignite B					...	6 300	

[1]This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 percent dry, mineral-matter-free fixed carbon or have more than 15,500 moist, mineral-matter-free British thermal units per pound.

[2]Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[3]If agglomerating, classify in low-volatile group of the bituminous class.

[4]Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[5]It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high volatile C bituminous group.

Table 14 --Proximate, ultimate, Btu, and forms-of-sulfur analyses of samples of the Smirl and Bald Knoll coal zones in the Dakota Formation (Cretaceous age), Alton coal field, Kane County, Utah. (All analyses except Btu are in percent. Original moisture content may be slightly more than shown because samples were collected and transported in plastic bags to avoid metal contamination. Form of analyses: A, as received; B, moisture free; C, moisture and ash free. All analyses by Coal Analysis Section, U.S. Bureau of Mines, Pittsburgh, Pa.)

SAMPLE NO.	FORM OF ANALYSIS	PROXIMATE ANALYSIS				ULTIMATE ANALYSIS					BTU VALUE	FORMS OF SULFUR		
		Moisture	Volatile matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur		Sulfate	Pyritic	Organic
Smirl zone, face channel sample, Test Trench 102, 10 ft thick with a 0.6 ft thick mudstone parting included, SW 1/4, sec. 13, T. 40 S., R. 5 W.														
D169563	A	29.9	30.3	29.2	10.6	5.8	39.3	0.9	42.1	1.3	6260	0.64	0.07	0.58
	B	--	43.2	41.7	15.1	3.5	56.0	1.3	22.3	1.8	8930	.91	.10	.83
	C	--	50.9	49.1	--	4.1	66.0	1.5	26.2	2.2	10520	1.07	.12	.98
Smirl zone, composite core bench sample, Drill Hole 101, depth 200.0 to 214.3 ft, SW 1/4, sec. 8, T. 40 S., R. 4 1/2 W.														
D169559	A	19.9	34.1	37.7	8.3	6.0	55.0	1.0	28.3	1.4	9540	0.01	0.54	0.83
	B	--	42.5	47.2	10.3	4.7	68.7	1.3	13.3	1.7	11900	.01	.68	1.03
	C	--	47.4	52.6	--	5.3	76.6	1.4	14.8	1.9	13270	.01	.76	1.16
Smirl zone, composite core bench sample, Drill Hole 103, depth 191.0 to 204.0 ft, SW 1/4, sec. 8, T. 40 S., R. 4 1/2 W.														
D169560	A	21.3	31.4	38.9	8.4	6.0	54.1	1.0	29.3	1.2	9370	0.02	0.57	0.65
	B	--	39.9	49.4	10.7	4.6	68.8	1.3	13.0	1.6	11910	.02	.72	.83
	C	--	44.6	55.4	--	5.2	77.0	1.4	14.6	1.8	13330	.02	.81	.93
Smirl zone, composite core grab sample, Drill Hole 104, depth 80.6 to 97.9 ft, SW 1/4, sec. 18, T. 40 S., R. 4 1/2 W.														
D169763	A	21.9	32.6	40.7	4.8	6.3	56.2	1.1	31.0	0.6	9780	0.02	0.14	0.46
	B	--	41.8	52.1	6.1	5.0	71.9	1.4	14.8	0.8	12520	.02	.18	.59
	C	--	44.5	55.5	--	5.3	76.6	1.5	15.8	0.8	13330	.02	.19	.63
Bald Knoll zone, composite core grab sample, Drill Hole 104, depth 264.6 to 283.7 ft, 0.6 ft mudstone not included, SW 1/4, sec. 18, T. 40 S., R 4 1/2 W.														
D169764	A	16.2	28.2	34.7	20.9	5.3	46.6	0.9	25.3	1.0	8120	0.01	0.45	0.51
	B	--	33.6	41.5	24.9	4.2	55.6	1.0	13.1	1.2	9700	.01	.54	.61
	C	--	44.8	55.2	--	5.6	74.1	1.4	17.4	1.5	12920	.01	.72	.81
Smirl zone, composite core grab sample, Drill Hole 105, depth 169.2 to 186.6 ft, NW 1/4, SW 1/4, sec. 13, T. 40 S., R. 5 W.														
D169765	A	20.6	31.8	40.2	7.4	6.1	54.5	1.1	30.0	0.9	9530	0.01	0.18	0.73
	B	--	40.0	50.7	9.3	4.8	68.6	1.4	14.8	1.1	11990	.01	.22	.91
	C	--	44.1	55.9	--	5.3	75.6	1.5	16.3	1.3	13210	.01	.25	1.01

the semicommercial "type" classification commonly used in the coal fields of the eastern United States (U.S. Bureau of Mines, 1965, page 123). However, most of the type classifications are based on the same, or similar, gross distinctions in plant material used by Tomkeieff (1954, Table II, and page 9), who divided the coals into three series: humic coals, humic-sapropelic coals, and sapropelic coals, based upon the nature of the original plant materials. The humic coals are largely composed of the remains of the woody parts of plants and the sapropelic coals are largely composed of the more resistant waxy, fatty, and resinous parts of plants, such as cell walls, spore-coatings, pollen, resin particles, and coals composed mainly of algal material. Most coals fall into the humic series, with some coals being mixtures of humic and sapropelic elements and, therefore, falling into the humic-sapropelic series. The sapropelic series is quantitatively insignificant and when found is commonly regarded as an organic curiosity.

In common with most coals of the United States, the Alton coals fall largely in the humic series.

3. Grade of Coal

Classification of coal by grade, or quality, is based largely on the content of ash, sulfur, and other constituents that adversely affect utilization. Most detailed coal resource evaluations of the past do not categorize known coal resources by grade but coals of the United States have been classified by sulfur content in a gross way (DeCarlo and others, 1966).

The range and average of the ash and sulfur contents of 642 coals from all parts of the United States were determined by Fieldner, Rice, and Moran (1942).

Ash and sulfur contents of United States coals as received

Number of samples	Ash, percent		Sulfur, percent	
	Range	Average	Range	Average
642	2.5 - 32.6	8.9	0.2 - 7.7	1.9

The ash and sulfur content of the four cored samples from the Smirl coal zone in the Alton Field, as determined by the Bureau of Mines analyses, are: ash-range 4.8 to 8.4 percent, average 7.2 percent; sulfur-range 0.6 to 1.4 percent,

average 1.0 percent. The sample from the lower or Bald Knoll coal zone in DH-104 showed ash 20.9 percent and sulfur 1.0 percent.

C. Geologic Setting

The geologic map of the area around and including the Alton EMRIA site (Drawing No. 1224-0A-300-46) shows the outcrop of the upper (Smirl) coal zone and location of the drill holes. Lithologic logs of the drill holes are shown on Figure 13.

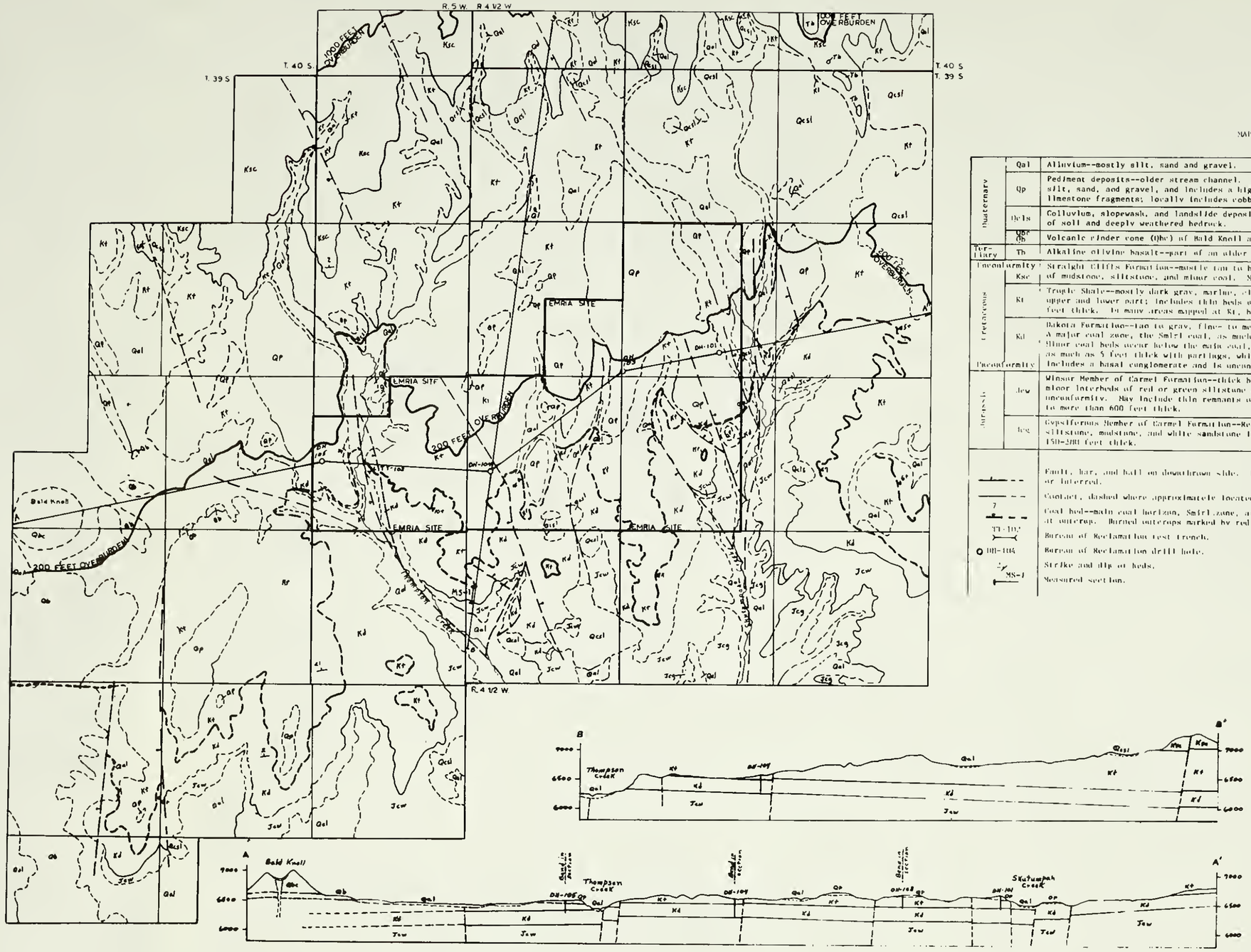
The coal of the Alton area is in the Dakota formation of Cretaceous Age. Two important coal zones, the upper or Smirl, and the lower, or Bald Knoll, contain all of the coal of potential economic importance. The Smirl zone at the top of the Dakota contains thicker coal beds than does the Bald Knoll and was the primary target of the drilling and trenching program conducted as part of the present investigation (Figure 13). Two of the drill holes were extended below the Smirl zone to obtain information and samples about the rocks and coalbeds between the Smirl zone and the base of the Dakota formation.

The Dakota formation unconformably overlies the Winsor member of the Carmel formation of Jurassic Age and conformably underlies the Tropic Shale of Cretaceous Age. The Tropic is composed of marine shale with a few very thin interbeds of very fine-grained sandstone and bentonitic clay.

Surficial deposits of several different types, all of Quaternary Age, unconformably overlie and mask the older rock units. As shown on Figure 13, the surficial deposits range widely in thickness and only detailed examination of potential surface-mining areas will yield definitive data on the distribution of the different rock materials overlying the coalbeds in the area.

D. Estimation and Classification of Coal Resources

Preparation of a coal resource estimate involves certain procedures and definitions that have been established in an attempt to standardize, insofar as possible, coal resource appraisals in the United States. As used in this report, the term "coal resource" designates the estimated quantity of coal in the ground in such form that economic extraction is currently or potentially feasible.



MAP EXPLANATION

Quaternary	Qal	Alluvium--mostly silt, sand and gravel.
	Qp	Pediment deposits--older stream channel. Fan and terrace deposits above present drainage composed mostly of silt, sand, and gravel, and includes a high percentage of subangular to subrounded pebble to boulder-size limestone fragments; locally includes cobbles and boulders of basalt. 0-100 feet thick.
	Qcls	Colluvium, slopewash, and landslide deposits; undifferentiated--material varies with source and includes areas of soil and deeply weathered bedrock.
	Qbc Qb	Volcanic cinder cone (Qbc) of Bald Knoll and related flows of olivine basalt (Qb).
Tertiary	Tb	Alkaline olivine basalt--part of an older basalt flow making a high ridge to the northeastern part of the area.
Unconformity		
Cretaceous	Ksc	Straight Cliffs Formation--mostly tan to buff, fine- to medium-grained, cliff-forming sandstone with interbeds of mudstone, siltstone, and minor coal. More than 600 feet thick.
	Kt	Tropic Shale--mostly dark gray, marine, claystone or shale with some tan very fine grained sandy beds in upper and lower part; includes thin beds of bentonite and limestone concretions in lower part. About 700 feet thick. In many areas mapped at Kt, bedrock is obscured by soil or slopewash.
	Kd	Dakota Formation--tan to gray, fine- to medium-grained sandstone, mudstone, carbonaceous mudstone and coal. A major coal zone, the Smirl coal, as much as 20 feet thick, occurs at or near the top of the formation. Minor coal beds occur below the main coal, the most important of which is the lower or Bald Knoll coal zone, as much as 5 feet thick with partings, which is 20 to 50 feet above the base. The formation locally includes a basal conglomerate and is unconformable on underlying Jurassic rocks. About 200 to 240 feet thick.
Unconformity		
Jurassic	Jcw	Winsor Member of Carmel Formation--thick beds of friable brown, white or yellow fine-grained sandstone with minor interbeds of red or green siltstone and mudstone. Thins westward, truncated by the pre-Dakota unconformity. May include thin remnants of overlying Entrada sandstone locally at top. Ranges from 200 to more than 600 feet thick.
	Jcg	Gypsiferous Member of Carmel Formation--Red medium-grained, friable sandstone with minor green or red siltstone, mudstone, and white sandstone interbeds; includes a thick gypsum bed at the base. About 150-200 feet thick.

- Fault, bar, and ball on downthrown side. Dashed where approximately located, short dashed where covered or inferred.
- Contact, dashed where approximately located.
- 7 — Coal bed--main coal horizon, Smirl zone, at top of Dakota Formation showing thickness in feet observed at outcrop. Burned outcrops marked by red clinker zones and poor exposures are typical of the study area.
- TT-101 — Bureau of Reclamation test trench.
- DH-104 — Bureau of Reclamation drill hole.
- MS-1 — Strike and dip of beds.
- Measured section.

Geology modified after Goode (1973) and mapping by Utah International, Inc., 1963-1969. Base maps - Bald Knoll and Skutumpah Creek USGS topographic maps.

Scale 1:24,000

1 mile

1 kilometer

Utah

Location

Geologic map and structure sections of the EMRIA site and adjoining area

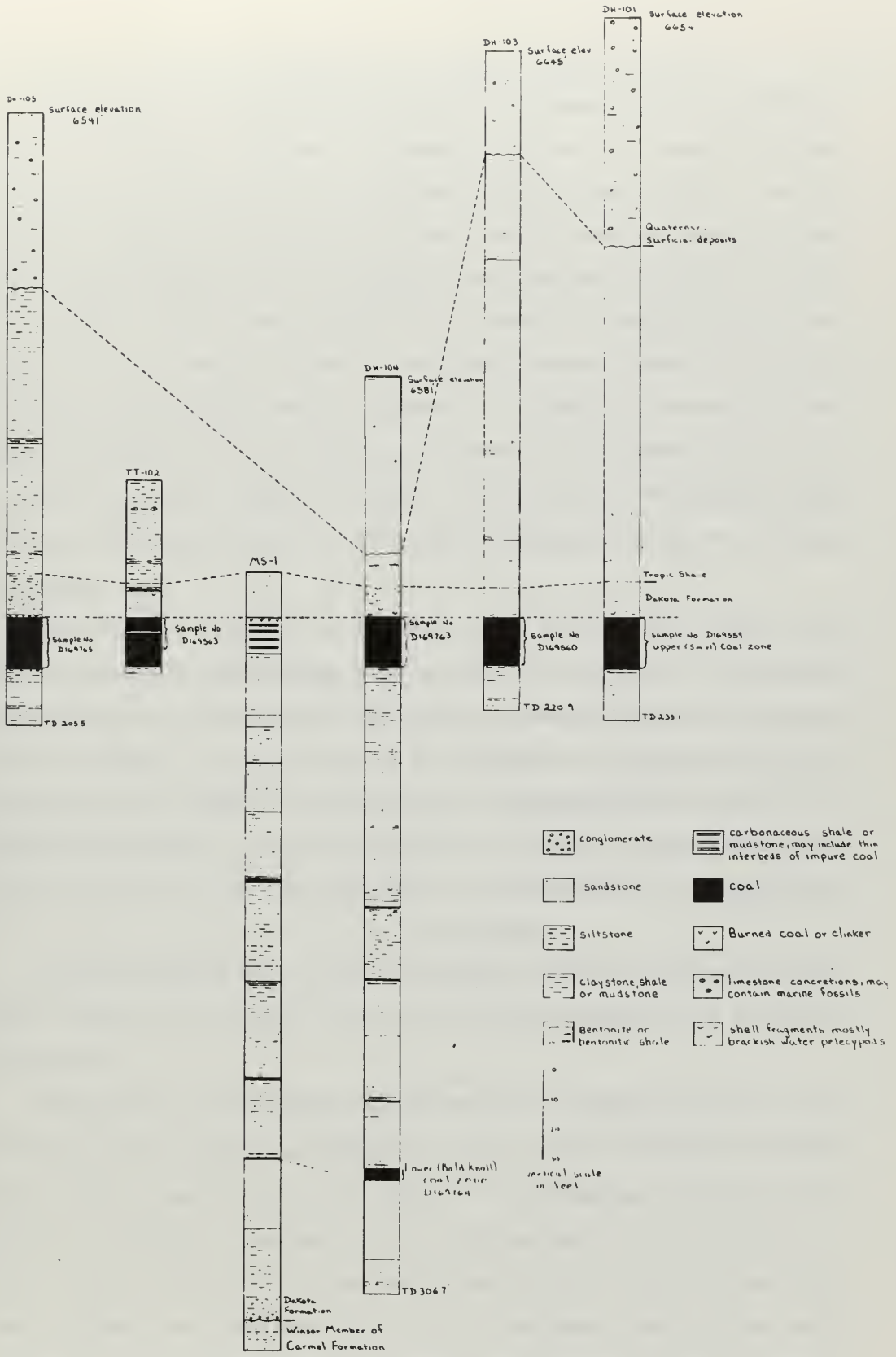


Fig.13 - Lithologic logs of drill holes in the Alton EMRIA site

1. Tabulation of Estimated Coal Resources

Tables 15 and 16 summarize the estimated coal resources of the Alton EMRIA site–about 3.6 square miles, and of a larger area–about 26.9 square miles–that is composed of the EMRIA site proper and adjoining areas. Table 17 lists the estimated resources of the area in a more detailed form. In accordance with conventions adopted by the U.S. Geological Survey and the U.S. Bureau of Mines, the resources in the Alton EMRIA site are classed as "identified-subeconomic resources"–that is, specific bodies of coal whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category, and that are presently classed as subeconomic because the estimated tonnage of coal is in beds that are not presently classed as reserves, but may become so as a result of changes in economic and legal conditions.

The estimated identified coal resources shown in Tables 15, 16, and 17 fall into a category called Reserve Base, which is defined as that portion of the identified coal resource from which reserves are calculated. Reserves in the strict sense used here are defined as "that portion of the identified coal resource that can be economically and legally mined at the time of determination--also referred to as Recoverable Reserve. The reserve is derived by applying a recoverability factor to that component of the identified coal resource designated as the Reserve Base."

2. Recoverability

The recoverability factor is "the percentage of total tons of coal producible from a given area in relation to the total tonnage estimated to be in place in the ground."

Recoverability determinations can be made (1) by using mine maps, (2) from production versus reserve base estimates, or (3) by using an average recoverability factor based on past experience (see below). All coal remaining in the ground after mining is completed is considered as lost in mining and includes coal that is (1) left to support mine roofs, (2) too thin to mine, (3) left unmined beneath rivers, lakes, highways, and legal reservations, (4) left unmined around oil, gas, water, and disposal wells, (5) left unmined as barrier pillars adjacent to mine or property

Table 15--Summary of estimated identified coal resources of the Smirl zone in the Alton EMRIA site

[In thousands of tons]

	Overburden thickness (feet)			
	0-200	200-1,000	More than 1,000	Total
Coal beds 5 to 10 feet thick				
Demonstrated[1] resources	520	--	--	520
Inferred resources	--	--	--	--
Total	520			520
Coal beds more than 10 feet thick				
Demonstrated[1] resources	26,727	21,385	--	48,112
Inferred resources	--	--	--	--
Total	26,727	21,385		48,112
Total identified resources	27,247	21,385	--	48,632

[1]A collective term for the sum of coal in both measured and indicated resources.

Table 16 --Summary of estimated identified coal resources of the Smirl zone in the area around and including the Alton EMRIA site

[In thousands of tons]

	Overburden thickness (feet)			
	0-200	200-1,000	More than 1,000	Total
Coal beds 5 to 10 feet thick				
Demonstrated[1] resources	4,804	--	--	4,804
Inferred resources	--	--	--	--
Total	4,804	--	--	4,804
Coal beds more than 10 feet thick				
Demonstrated[1] resources	85,953	85,128	--	171,081
Inferred resources	2,577	127,595	2,684	132,856
Total	88,530	212,723	2,684	303,937
Total identified resources	93,334	212,723	2,684	308,741

[1]A collective term for the sum of coal in both measured and indicated resources.

Table 17 -Estimated coal rasourcee of the Smirl zone in the area around and including the Alton EMRIA sita

[In thousands of tone]

Thickness of overburden (feet)	Location	5 to 10 feet thick			More than 10 feet thick			Totals		
		Demonstrated	Inferred	Total	Demonstrated	Inferred	Total	Demonstrated	Inferred	Total
0 - 200		--	--	--	--	--	--	--	--	--
200 - 1000	T. 39 S., R. 4 1/2 W.	--	--	--	--	19,035	19,035	--	19,035	19,035
>1000		--	--	--	--	655	655	--	655	655
Total		--	--	--	--	19,690	19,690	--	19,690	19,690
0 - 200		--	--	--	--	--	--	--	--	--
200 - 1000	T. 39 S., R. 5 W.	--	--	--	--	5,300	5,300	--	5,300	5,300
>1000		--	--	--	--	2,029	2,029	--	2,029	2,029
Total		--	--	--	--	7,329	7,329	--	7,329	7,329
0 - 200		3,790	--	3,790	37,176	--	37,176	40,966	--	40,966
200 - 1000	T. 40 S., R 4 1/2 W.	--	--	--	43,031	44,297	87,328	43,031	44,297	87,328
>1000	(including EMRIA site)	--	--	--	--	--	--	--	--	--
Total		3,790	--	3,790	80,207	44,297	124,504	83,997	44,297	128,294
0 - 200		179	--	179	20,325	--	20,325	20,504	--	20,504
200 - 1000	T. 40 S., R. 4 1/2	--	--	--	18,130	--	18,130	18,130	--	18,130
>1000	(EMRIA site only)	--	--	--	--	--	--	--	--	--
Total		179	--	179	38,455	--	38,455	38,634	--	38,634
0 - 200		1,014	--	1,014	48,777	2,577	51,354	49,791	2,577	52,368
200 - 1000	T. 40 S., R. 5 W.	--	--	--	42,097	58,963	101,060	42,097	58,963	101,060
>1000	(including EMRIA site)	--	--	--	--	--	--	--	--	--
Total		1,014	--	1,014	90,874	61,540	152,414	91,888	61,540	153,428
0 - 200		341	--	341	6,402	--	6,402	6,743	--	6,743
200 - 1000	T. 40 S., R. 5 W.	--	--	--	3,255	--	3,255	3,255	--	3,255
>1000	(EMRIA site only)	--	--	--	--	--	--	--	--	--
Total		341	--	341	9,657	--	9,657	9,998	--	9,998
0 - 200		4,804	--	4,804	85,953	2,577	88,530	90,757	2,577	93,334
200 - 1000	Entire area including	--	--	--	85,128	127,595	212,723	85,128	127,595	212,723
>1000	EMRIA site	--	--	--	--	2,684	2,684	--	2,684	2,684
Total		4,804	--	4,804	171,081	132,856	303,937	175,885	132,856	308,741
0 - 200		520	--	520	26,727	--	26,727	27,247	--	27,247
200 - 1000	Total EMRIA site only	--	--	--	21,385	--	21,385	21,385	--	21,385
>1000		--	--	--	--	--	--	--	--	--
Total		520	--	520	48,112	--	48,112	48,632	--	48,632

boundaries, and (6) left unmined because of environmental, safety, quality, or hydrologic considerations. Coal losses incurred during cleaning and preparation are not considered when determining recoverability. Recoverability determined in existing mined areas can be projected to similar unmined areas, assuming other conditions equal, to calculate reserves from reserve base. In the U.S., recoverability in underground mining ranges from 10 to 80 percent, depending on variables such as the thickness of coalbed, security of roof and floor rock, operator, and mining method, but nationally it is about 50 percent. Recoverability for strip mining is locally as great as 90 percent, but studies indicate that nationally it averages about 50 percent owing to barriers left to protect mine boundaries, to restrictions on highwalls, and to restrictions about mining near lakes, streams, railroads, highways, and farmed areas.

3. Resources Categorized by Degree of Geologic Assurance

Two categories according to degree of geologic assurance were used in the present study.

Demonstrated - Composed of both measured resources, which have been estimated from closely spaced and geologically well-known measurements and sample sites to within a margin of error of less than 20 percent, and indicated resources, which have been estimated partly from sample analyses and measurements and partly from reasonable geologic projections.

Inferred - Coal in unexplored extensions of demonstrated resources for which estimates of the quality and size are based on geologic evidence and projection.

Resources estimated for the Alton EMRIA site and listed in the tables as demonstrated resources are in bodies of coal whose outer limits are within three-fourths of a mile of points of information. Inferred resources are in bodies of coal whose inner boundaries are bodies of demonstrated resources and whose outer boundaries are as much as three miles from points of observation.

4. Characteristics Used in Resource Evaluation

The coal characteristics that are commonly used in classifying coal resources are the rank, grade, and weight of the coal, the thickness and areal extent of the coalbeds, and the thickness of the overburden. The rank and grade of the coal sampled as part of this study have been discussed previously.

a. Weight

The weight of the coal ranges considerably with differences in rank and ash content. In areas such as the Alton Field where true specific gravities of the coals have not been determined, an average specific gravity value based on many determinations in other areas is used to express the weight of the coal for resource calculations. The average weight of subbituminous coal is taken as 1,770 tons per acre-foot–a specific gravity of 1.30.

b. Thickness of Beds

Because of the important relation of coalbed thickness to utilization potential, most coal resource estimates prepared by the U.S. Geological Survey are tabulated according to three thickness categories. For subbituminous coal, the categories are: thin–2.5 to 5 feet; intermediate–5 to 10 feet; and thick–more than 10 feet. About two percent of the estimated resources of the study area are in the intermediate category, and about 98 percent are in the thick category. By way of comparison, Averitt (1969, Figure 5 and page 37) shows the distribution of the estimated resources of 21 States as 44 percent in beds in the thin category, 27 percent in the intermediate category, and 29 percent in the thick category. In the EMRIA site proper, about 1 percent of the estimated resources is in the intermediate category, and about 99 percent are in the thick category.

Coalbed thicknesses used in calculating resource estimates were derived from both isopach maps and weighted average thicknesses. Bed-thickness maps were prepared where the distribution of data allowed, but in some areas, particularly in areas of isolated and widely spaced outcrop data, weighted average thicknesses of coalbeds in the area were derived. The total area of coal of all classes in each bed may be determined in several ways: Where the continuity of the bed is well established by maps of the outcrops, mine working, drill holes, etc., as in the

Pittsburgh bed of the eastern United States, the entire area of known occurrency may be taken, even though points of observation are widely spaced. Persistent beds that have been traced around a basin or spur may be considered to underlie the area enclosed by the outcrop. A length of outcrop within the thickness limits listed above is considered to establish the presence of coal of all classes in appropriately spaced belts roughly parallel to and inside the outcrop. An isolated drill hole may be considered to determine an area of coal of each class extending for an appropriate radius around the hole.

c. Thickness of Overburden

Coal resources are commonly divided into categories based on the thickness of overburden in feet as follows: 0-1,000, 1,000-2,000, and 2,000-3,000. However, since the present study is aimed at areas where the coal resources can be recovered by surface mining methods, resources were also estimated for depths of 200 feet or less, a parameter that probably reflects present capabilities of earth moving equipment used in surface mining.

E. Summary of Resources

Total estimated identified original coal resources in the Alton EMRIA site and adjoining area is 308,741,000 tons. Coalbeds from 5 to 10 feet thick make up 4,804,000 tons of the estimated resources and beds more than 10 feet thick make up 303,937,000 tons.

Coalbeds in the study area are commonly burned along the outcrop and may be burned back as much as 100 feet from the outcrop face. In areas under shallow overburden, the coal may have burned over much of the area. Resource estimates for this report were calculated for all areas behind the outcrop and includes some areas where coal is actually no longer present due to burning.

The estimated identified original coal resources with 200 feet or less of overburden in the Smirl zone in the Alton EMRIA site and adjoining area total 93,334,000 short tons, of which 90,757,000 tons are classed as demonstrated (measured plus indicated), and 2,577,000 tons are classed as inferred resources. Beds more than 10 feet thick make up 88,530,000 tons of the estimated resources with 200 feet or less of overburden.

In the EMRIA site proper, an area of about 3.6 square miles, the estimated identified original coal resources with 200 feet or less of overburden total 27,247,000 tons. All of the coal resources within the EMRIA site are classed as demonstrated (measured plus indicated) resources. Coalbeds from 5 to 10 feet thick make up 520,000 tons, and beds more than 10 feet thick make up 26,727,000 tons.

The estimated resources presented in this report are original resources, that is, resources in the ground before the beginning of mining operations.

F. Composition

Eight core samples from the Alton area were analyzed for trace elements following the procedure shown on Figure 14, as an aid in solution of problems of coal utilization. The Geological Survey Analytical Laboratories routinely provide the following analytical determinations on all samples:

1. Major composition of the ash of coal–percent ash, SiO_2, Al_2O_3, Na_2O, K_2O, CaO, MgO, Fe_2O_3, P_2O_5, Cl, MnO, TiO_2, and SO_3.

2. Trace element composition of coal

   a. Individual quantitative determinations–p/m As, Cd, Cu, F, Hg, Li, Pb, Sb, Se, Th, U, and Zn.

   b. Semiquantitative spectrographic analysis–p/m of 20-30 elements detected by this method.

   c. Individual quantitative determinations, of abnormal amounts indicated by semiquantitative analysis, or on spot-check basis–p/m Ag, Au, Be, Vi, Ge, Mo, Ni, Te, Tl, and V.

Results of the analytical determinations are listed here in Tables 18, 19, and 20.

Table 21 compares analyses of seven samples of the Smirl coal zone in the Alton area to 67 samples of subbituminous coals from various locations in the Powder River Basin of Wyoming and Montana (Swanson, Huffman, and Hamilton, 1974). The higher heat value (Btu) and slightly larger fixed carbon content of the Smirl coal as compared to the average of subbituminous coals in the Powder River Basin is a direct reflection of the higher rank (greater degree of metamorphism) of the Smirl coal.

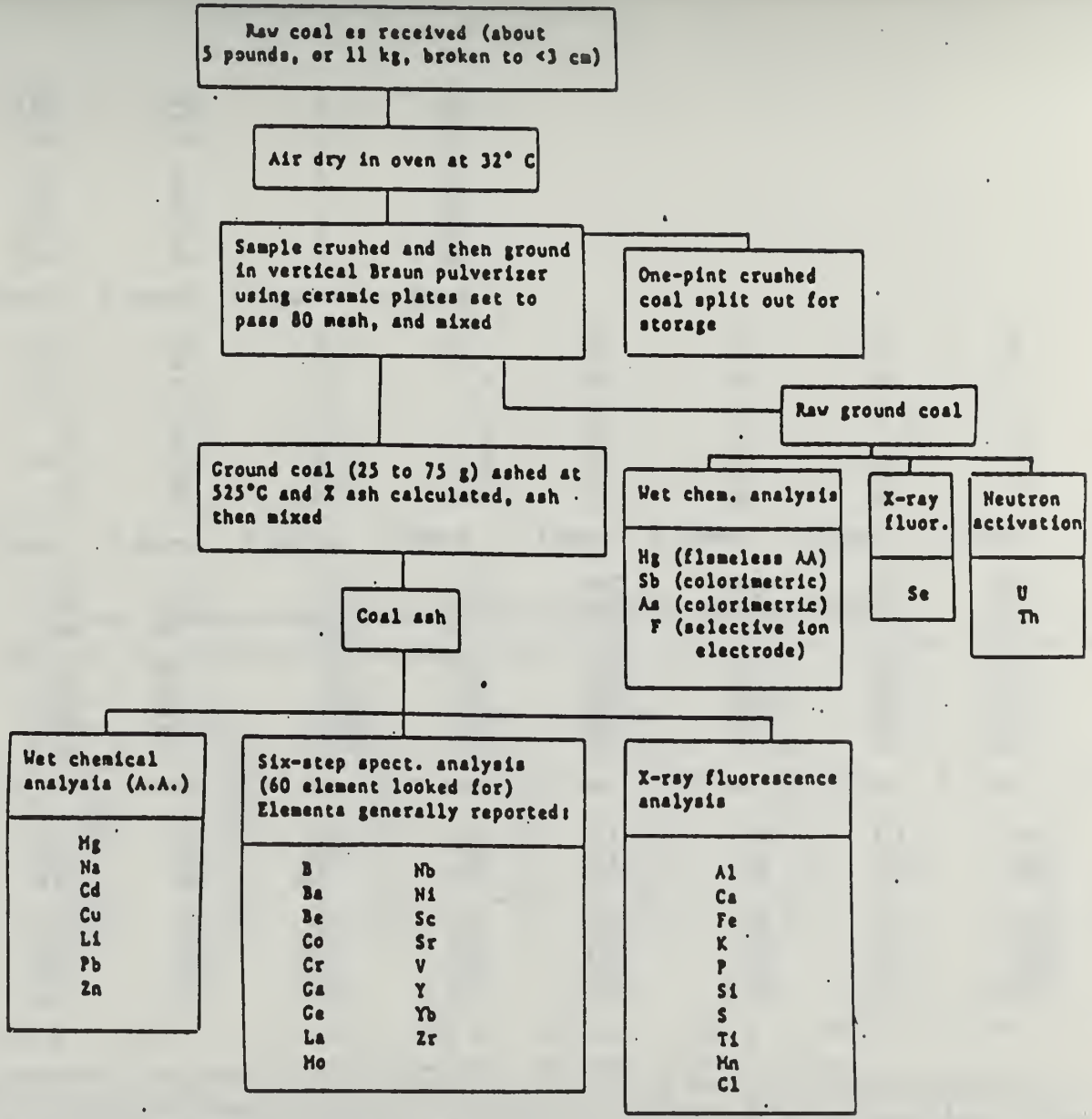


Figure 14.-- Sequence of sample preparation and analysis.

Table 18 --Major and minor oxide and trace element composition of the laboratory ash of eight samples from the Alton area, Utah

[Values are in either percent or parts per million. The coals were ashed at 525°C. L after a value means less than the value shown, N means not detected, and B means not determined. S after the element title means that the values listed were determined by semiquantitative spectrographic analysis. The spectrographic results are to be identified with geometric brackets whose boundaries are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc., but are reported arbitrarily as mid-points of those brackets, 1.0, 0.7, 0.5, 0.3, 0.2, 0.15, 0.1, etc. The precision of the spectrographic data is approximately one bracket at 68 percent, or two brackets at 95 percent confidence. See figure 3 for sample location]

SAMPLE	Ash %	SiO_2 %	Al_2O_3 %	CaO %	MgO %	Na_2O %	K_2O %	Fe_2O_3 %	MnO %	TiO_2 %
D169559	9.60	35.	24.	9.3	2.6	1.6	0.12	8.2	0.020L	1.1
D169560	10.7	38.	17.	8.2	1.4	2.8	.06	12.	.020L	1.1
D169561	8.60	29.	21.	10.	2.0	5.0	.12	5.0	.020L	.75
D169562	9.20	21.	16.	14.	1.7	2.5	.32	14.	.020L	.60
D169563	13.8	46.	19.	5.9	1.3	2.4	.74	9.3	.020L	.79
D169763	6.20	34.	21.	14.	4.0	1.0	.11	4.0	.020L	1.1
D169764	25.3	54.	35.	2.3	.68	1.1	.28	4.6	.020L	1.3
D169765	11.7	39.	28.	6.5	1.5	2.4	.32	4.1	.020L	.75

SAMPLE	Cl %	P_2O_5 %	SO_3 %	Cd PPM	Cu PPM	Li PPM	Pb PPM	Zn PPM	B PPM-S	Be PPM-S
D169559	0.10L	0.10L	19.	1.L	74.	314.	25.	27.	1500	500
D169560	.10L	.10L	18.	1.L	82.	326.	40.	20.	1000	1500
D169561	.10L	.10L	27.	1.L	68.	220.	25.L	50.	1000	500
D169562	.10L	.10L	29.	1.L	60.	98.	30.	39.	500	700
D169563	.10L	.10L	15.	1.L	60.	170.	25.	48.	1000	500
D169763	.10L	.10L	18.	1.L	106.	158.	40.	32.	2000	1500
D169764	.10L	.10L	3.4	1.L	62.	122.	65.	98.	300	200
D169765	.10L	.10L	1.2	1.L	54.	210.	50.	45.	1000	700

SAMPLE	Be PPM-S	Co PPM-S	Cr PPM-S	Ga PPM-S	Ge PPM-S	La PPM-S	Mo PPM-S	Nb PPM-S	Ni PPM-S	Sc PPM-S
D169559	5	L	50	50	30	N	10	20	15	15
D169560	N	L	30	30	N	70	15	20	20	15
D169561	5	10	30	30	N	70	10	20	15	15
D169562	N	L	20	30	N	70	7	L	20	10
D169563	N	L	30	30	N	70	10	L	15	15
D169763	3	15	50	30	N	100	15	20	30	15
D169764	15	15	20	50	50	200	30	20	15	15
D169765	5	15	30	50	20	70	7	20	20	10

SAMPLE	Sr PPM-S	V PPM-S	Y PPM-S	Yb PPM-S	Zr PPM-S
D169559	2000	150	20	3	200
D169560	2000	100	20	5	200
D169561	2000	100	30	5	150
D169562	2000	70	30	3	100
D169563	1000	150	30	3	200
D169763	2000	100	50	3	200
D169764	500	150	100	15	200
D169765	1000	100	30	3	150

Table 19—Content of seven trace elements in eight samples from the Alton area, Utah

[Analyses on air-dried (32°C.) coal. All values are in parts per million. L after a value means less than the value shown, B means not determined]

SAMPLE	As PPM	F PPM	Hg PPM	Sb PPM	Se PPM	Th PPM	U PPM
D169559	1.	20.	0.09	0.4	0.6	4.4	1.2
D169560	4.	30.	.31	.5	1.3	3.1	1.1
D169561	1.	80.	.09	.4	.3	2.6	1.6
D169562	5.	20.L	.32	.4	.8	2.0L	1.1
D169563	5.	95.	.17	.5	.6	4.7	2.7
D169763	1.	20.	.06	.4	.5	2.0L	.5
D169764	5.	135.	.19	5.2	1.5	16.8	9.5
D169765	2.	35.	.14	1.0	.7	8.8	2.0

Table 20--Major, minor and trace element composition of eight samples from the Alton area, Utah, reported on whole-coal basis

[Values are in either percent or parts per million. Al, Ca, Fe, Mg, Na, K, Si, Cl, Mn, P, Ti, Cd, Cu, Li, Pb, and Zn values were calculated from analyses of ash. As, F, Hg, Sb, Se, Th and U values are from direct determinations on air-dried (32°C.) coal. The remaining analyses were calculated from spectrographic determinations on ash. L after a value means less than the value shown, N means not detected, and B means not determined]

SAMPLE	Si %	Al %	Ca %	Mg %	Na %	K %	Fe %	Mn PPM	Ti %	Cl %
D169559	1.6	1.2	0.64	0.15	0.11	0.010	0.55	15.L	0.065	0.010L
D169560	1.9	.97	.63	.089	.22	.006	.91	17.L	.069	.011L
D169561	1.2	.96	.64	.10	.32	.008	.30	13.L	.039	.009L
D169562	.90	.78	.93	.096	.17	.024	.87	14.L	.033	.009L
D169563	3.0	1.4	.58	.11	.25	.085	.90	21.L	.066	.014L
D169763	1.0	.70	.62	.15	.046	.006	.17	10.L	.042	.006L
D169764	6.4	4.6	.42	.10	.21	.060	.81	39.L	.20	.025L
D169765	2.1	1.7	.54	.11	.21	.032	.33	18.L	.052	.017L

SAMPLE	P PPM	As PPM	Cd PPM	Cu PPM	F PPM	Hg PPM	Li PPM	Pb PPM	Sb PPM	Se PPM
D169559	42.L	1.	0.1L	7.1	20.	0.09	30.1	2.4	0.4	0.6
D169560	47.L	4.	.1L	8.8	30.	.31	34.9	4.3	.5	1.3
D169561	38.L	1.	.1L	5.8	50.	.09	18.9	2.2L	.4	.3
D169562	40.L	5.	.1L	5.5	20.L	.32	9.0	2.8	.4	.8
D169563	60.L	5.	.1L	8.3	95.	.17	23.5	3.5	.5	.6
D169763	27.L	1.	.1L	6.6	20.	.06	9.8	2.5	.4	.5
D169764	110.L	5.	.3L	15.7	135.	.19	30.9	16.4	5.2	1.5
D169765	81.L	2.	.1L	6.3	35.	.14	24.6	5.9	1.0	.7

SAMPLE	Th PPM	U PPM	Zn PPM	B PPM-S	Ba PPM-S	Be PPM-S	Co PPM-S	Cr PPM-S	Ga PPM-S	Ge PPM-S
D169559	4.4	1.2	2.6	150	50	0.5	.5L	5	5	3
D169560	3.1	1.1	2.1	100	150	N	.5L	3	3	N
D169561	2.6	1.6	4.3	100	50	.5	1	2	2	N
D169562	2.0L	1.1	3.6	50	70	N	.5L	2	3	N
D169563	4.7	2.7	6.6	150	70	N	.5L	5	5	N
D169763	2.0L	.5	2.0	150	100	.2	1	3	2	N
D169764	16.8	9.5	24.8	70	50	3	3	5	15	15
D169765	8.8	2.0	5.3	100	70	.7	1.5	3	7	2

SAMPLE	La PPM-S	Mo PPM-S	Nb PPM-S	Ni PPM-S	Sc PPM-S	Sr PPM-S	V PPM-S	Y PPM-S	Yb PPM-S	Zr PPM-S
D169559	0.0N	1	2	2	1.5	200	15	2	0.3	20
D169560	7	1.5	2	2	1.5	200	10	2	.5	20
D169561	7	1	1.5	2	1.5	150	10	2	.5	15
D169562	7	.7	1 L	2	1	200	7	3	.3	10
D169563	10	1.5	1 L	2	2	150	20	5	.5	30
D169763	7	1	1.5	2	1	150	7	3	.2	15
D169764	50	7	5	3	3	150	30	20	3	50
D169765	7	.7	2	2	1	100	10	3	.3	15

Table 21.--Comparison of composition of Smirl zone coals with composition of subbituminous coals of the Northern Great Plains

	Smirl coal zone Kane County, Utah (7 samples)	Northern Great Plains subbituminous coals[1] (67 samples)
Moisture (as received)	20.9%[2]	20%
Fixed carbon (as received)	39.4%[2]	38%
Oxygen (as received)	29.7%[2]	30%
Btu (as received)	9,560[2]	9,000
SiO_2 (in ash)	35%	25%
Na_2O (in ash)	2.6%	0.5%
CaO (in ash)	9.9%	15%
MgO (in ash)	2.1%	4%
As (whole coal)	2.8 ppm	2 ppm
B (whole coal)	100 ppm	50 ppm
Ba (whole coal)	70 ppm	200 ppm
Hg (whole coal)	0.17 ppm	.08 ppm
Pb (whole coal)	3.3 ppm	6 ppm
U (whole coal)	1.5 ppm	0.7 ppm
Zn (whole coal)	3.8 ppm	7 ppm

[1]Swanson and other, 1974
[2]Four samples

Table 22 shows the range of and average elemental content on the whole-coal basis of those constituents commonly regarded as being of importance from the standpoint of coal utilization. Some of the elements, such as mercury and arsenic, are of interest because of the environmental problems that might occur if they are present in inordinate amounts; others such as thorium and uranium are of interest because they could be recovered from coal ash if they are present in sufficiently large quantities. Based on the 7.2 percent average ash content of the Smirl coal, trace elements such as thorium and uranium will be enriched in the ash approximately 14 times their whole-coal values.

In comparing the arithmetic mean of elements listed in Table 22 with an average value of these elements in the continental crust (Taylor, 1964), only selenium (average value about 0.7 p/m compared to 0.05 p/m average crustal abundance) and boron (average value about 100 p/m compared to 10 p/m average crustal abundance) are higher in the Smirl coal by more than an order of magnitude.

Beryllium, fluorine, nickel, zinc, and zirconium are all present in the Smirl coal in amounts that are less than the average crustal abundance of these elements by about an order of magnitude. The other trace elements are present in amounts that approximate (i.e., same order of magnitude) their abundances in the continental crust.

Table 22. --Elements that can affect potential utilization of coals--content in seven samples from the Smirl zone, Kane County, Utah

	Range ppm	Average ppm	Average continental crust ppm (Taylor, 1964)
As	1.0 → 5.0	2.8	1.8
Cd	<0.1	<0.1	0.2
Cu	5.5 → 8.8	6.9	55
F	<20 → 95	39	625
Hg	0.06 → 0.32	0.17	.08
Li	9.0 → 34.9	22	20
Pb	<2.2 → 5.9	3.3	12.5
Sb	0.4 → 1.0	0.51	0.2
Se	0.3 → 1.3	0.7	.05
Th	1.7 → 8.8	4.3	9.6
U	0.5 → 2.7	1.5	2.7
Zn	2.0 → 6.6	3.8	70
B	50 → 150	100	10
Be	.2 → .7	.3	2.8
Ni	2 → 2	2	70
Zr	10 → 30	15	165

V. HYDROLOGIC STUDIES

V. HYDROLOGIC STUDIES

A. Introduction

Hydrologic investigation of the Kanab study area included precipitation, surface water, and ground water from July 15 to November 13, 1974. Data were collected during monthly field trips except in the western part of the study area, which was inaccessible due to bad weather, during the July and November visits. Figure 15 shows the location of data-collection sites in and near the study area.

Data presented herein represent only conditions observed during the study period and should not be interpreted as representative of conditions which might occur over a long-term period. Data collected during other intervals or during a long-term period could lead to substantially different conclusions from data collected during this period.

Current plans are to continue observations for at least two more years.

B. Precipitation

Total precipitation on the study area drainage may be similar to amounts reported by nearby weather stations, but extreme variation in frequencies and intensities of individual storms is of primary concern, as severe flooding often results.

Five rain gages were established to indicate precipitation patterns throughout the area. Locations are shown on Figure 15. Precipitation accumulated between visits to the rain gages and for the same periods at Kanab, Alton, and Bryce Canyon National Park Headquarters' weather stations is shown on Table 23. These data show the localized effect of individual storms and the need to collect precipitation data at the study area rather than to rely on data from other weather stations. Table 24 shows variation in amount of July 16 to November 13 precipitation from 1965 to 1974 at the three weather stations.

C. Surface Water

1. Thompson Creek

Thompson Creek is a perennial stream that flows in a southerly direction through the western part of the study area. The channel is "V" shaped with steep unstable banks, and is composed mostly of clay. Lenses of coal outcrop on the

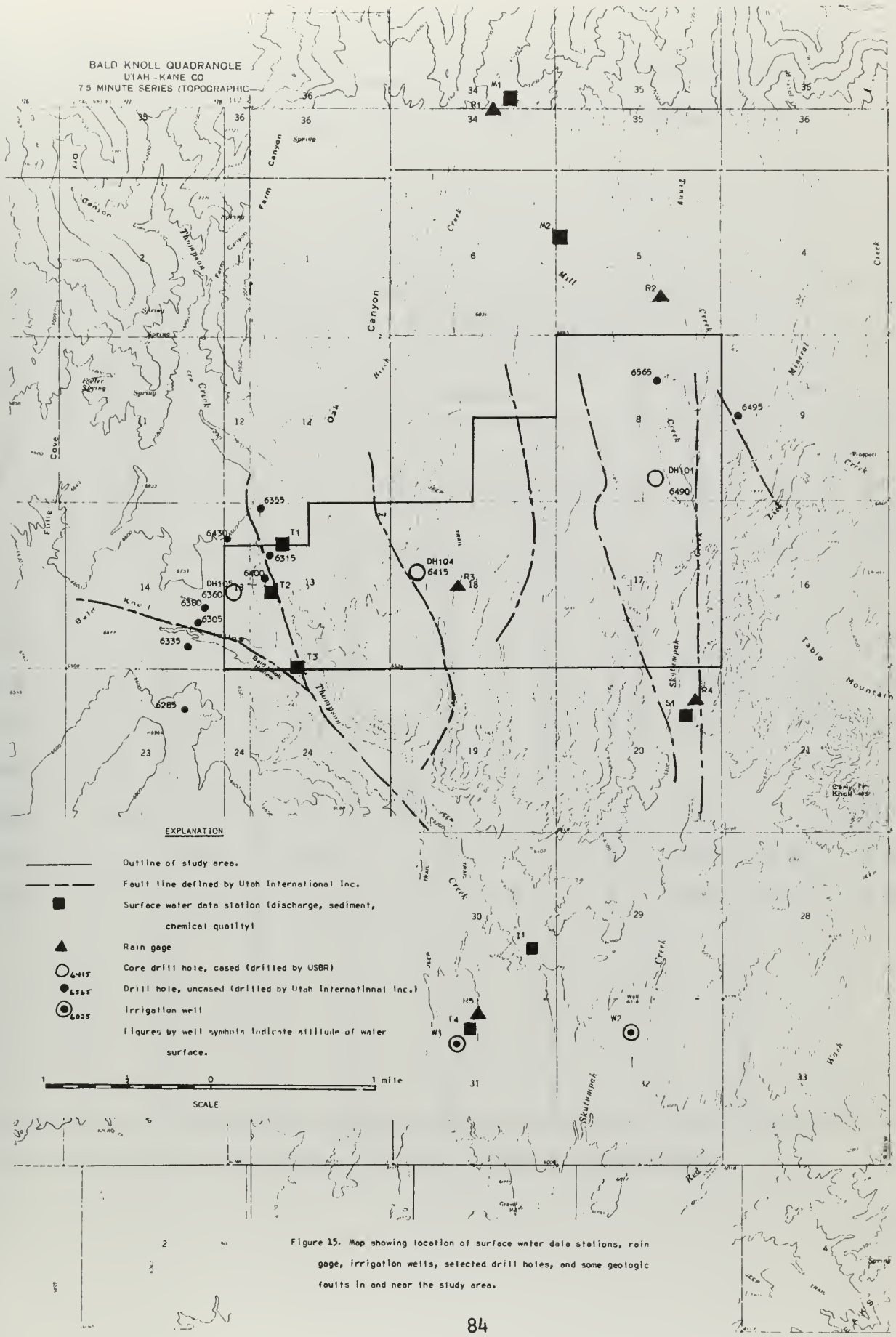


Figure 15. Map showing location of surface water data stations, rain gage, irrigation wells, selected drill holes, and some geologic faults in and near the study area.

Table 23.-- July 16 to November 13 precipitation in the study area and at Kanab, Alton, and Bryce Canyon NP Hdq. weather stations.

Date Visited	Elapsed time since previous visit (days)	Precipitation (inches)							
		Gages in study area					Weather Bureau Sta.		
		R-1	R-2	R-3	R-4	R-5	Kanab	Alton	Bryce Canyon NP Hdq.
7-16	-	-	-	-	-	-	-	-	-
7-17	1*	.5	.5	-	.4	.2	T	.04	.36
7-19	2	.1	.1	-	0	.1	.02	.09	.06
8-13	24	1.7	1.7	1.4	2.1	.5	.47	1.48	2.19
9-18	36	.4	.2	.6	.6	.7	.42	1.49	.57
10-17	29	1.3	1.4	1.0	1.3	1.2	.48	.9	1.07
11-13	27	3.5	3.5	-	-	2.8	4.61	3.07	2.25
Total	119	7.5	7.4	3.0	4.4	5.5	6.00	7.07	6.50

* occurred in 20 min. on afternoon of 7/16 at study area rain gages.

Table 24.—July 16 to November 13 precipitation, 1965-74 at Kanab, Alton, and Bryce Canyon NP Hdq. weather stations.

Year	Kanab	Alton	Bryce Canyon NP Hdq.
1965	2.27	5.76	5.10
1966	4.22	8.84	5.23
1967	5.01	6.22	7.84
1968	3.34	6.87	6.39
1969	6.35	5.76	4.73
1970	3.28	4.39	4.53
1971	5.42	7.41	7.37
1972	6.61	10.61	9.86
1973	.65	1.15	1.40
1974	6.00	7.07	6.50

banks and in the stream channel near the southern edge of the study area. Faults defined by Utah International Inc. (Figure 15) generally follow drainage patterns in the study area, and the steep banks of Thompson Creek may be the result of faulting in this drainage.

The western part of the study area was inaccessible during the stormy period that occurred in mid-July. Consequently, a surface-water data station consisting of a staff gage and an automatic sediment sampler was established about two miles south of the preferred site (site T-4 on Figure 15). This was the nearest accessible point to the study area during this time. Three additional stations were later established within the study area. Discharge and sediment data collected at the four sites are shown on Table 25.

Normal streamflow through the area from July 15 to November 13 was about 1/4 of a cubic foot per second (ft^3/s) and originated from springs and seeps north of the study area. Sediment load was small (Table 24), and the appearance of the water ranged from clear to murky. Rainstorms, however, caused the flow to increase to flood stages that contained large amounts of sediment. Appearance of the floodwater was dark gray to black. Data shown on Table 24 for July 15 and 20 show the increases in flows and sediment loads caused by storms and flooding. High watermarks of July 15 were the highest observed in the drainage. No high watermarks from previous years showed above this.

Estimated total annual flow was 850 acre-feet. This estimate was based on channel geometry methods of determining streamflow (Moore 1968).

Table 26 shows the chemical quality of water in Thompson Creek within the study area (site T-2) and below the study area (site T-4) during normal flow, and below the area during and shortly after floodflow. The analyses at both stations during normal flow were similar, but indicated a slight increase in value for most constituents at site T-4. Analysis of water collected during the July 15 flood showed larger values for most constituents and a smaller pH than for normal flow conditions. Values of most constituents increased and pH remained about the same after the flood receded and while flow conditions were still unstable (July 17). Values of the constituents decreased and pH increased when the flow stabilized (see analyses for site T-4 on Table 26).

Table 25.-- Discharge and sediment data at seven surface-water data sites.

Thompson Creek

Site	T-1			T-2			T-3			T-4		
		Sediment			Sediment			Sediment			Sediment	
Date	Q (cfs)	Mean Con (Mg/L)	Sed. Disch (tons/day)	Q (cfs)	Mean Con (Mg/L)	Sed. Disch (tons/day)	Q (cfs)	Mean Con (Mg/L)	Sed. Disch (tons/day)	Q (cfs)	Mean Con (Mg/L)	Sed. Disch (tons/day)
7-15	-	-	-	-	-	-	-	-	-	624 1)	-	-
7-15	-	-	-	-	-	-	-	-	-	40.2	431,000	46,800
7-17	-	-	-	-	-	-	-	-	-	.67	10,700	19
7-20	-	-	-	-	-	-	-	-	-	460	332,000 3)	412,00
8-13	-	-	-	.16	186	.8	-	-	-	.19	66	.0
9-18	-	-	-	.22	218	.13	-	-	-	.25	43	.0
10-17	.29	109	.09	.26	37	.03	.31	88	.07	.19	34	.0
11-13	-	-	-	-	-	-	-	-	-	.20	507	.2

Mill and Skutumpah Creeks and Intermediate Drainage

Site	M-1			M-2			S-1			I-1		
7-15	-	-	-	-	-	-	16.2	307,000	13,428	2 2)	132,000	713
7-17	-	-	-	-	-	-	.32	932	.80	10 2)	252,000 3)	6,800
7-20	-	-	-	-	-	-	373 1)	-	-	30 2,4)	551,000 3)	44,600
8-13	.20	-	-	.11	-	-	dry	-	-	-	-	-
9-18	-	-	-	.12	65	.02	.03 2)	154	.01	-	-	-
10-17	.16	-	-	.03	6	.00	dry	-	-	-	-	-
11-13	-	-	-	.25	99	.07	.25	495	.33	20 2,5)	291,000 3)	15,70

1) Slope-area measurement
2) Estimated
3) Sample collected by automatic sediment sampler
4) Probable date of flood
5) Flood probably occurred last of October

Table 6.--Chemical analyses of water from four surface-water sites, two wells, and two drill holes

Location	Source	Date	Temp. (°C)	Discharge (cfs)	Dissolved silica (SiO_2) (Mg/L)	Dissolved calcium (Ca) (Mg/L)	Dissolved magnesium (Mg) (Mg/L)	Dissolved sodium (Na) (Mg/L)	Dissolved potassium (K) (Mg/L)	Bicarbonate (HCO_3) (Mg/L)	Dissolved sulphate (SO_4) (Mg/L)	Dissolved chloride (Cl) (Mg/L)	Dissolved fluoride (F) (Mg/L)	Dissolved Nitrate plus Nitrate (N) (Mg/L)	Dissolved orthophosphate (PO_4) (Mg/L)	Dissolved boron (B) (Mg/L)	Dissolved solids (Sum of constituents) (Mg/L)	Dissolved solids (tons per acre foot)	Dissolved solids (tons per day)	Hardness (CaMg) (Mg/L)	Noncarbonate hardness (Mg/L)	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)
GROUND WATER																								
DH 101	Drill Hole 101	7/19/74	15	—	3.5	35	12	600	8.6	326	97[illegible]	69	[illegible].1	34	[illegible].03	36[illegible]	20[illegible]	2.73	---	140	[illegible]	22	[illegible]300	[illegible].1
DH 105	Drill Hole 105	7/19/74	14.5	—	11	65	1.9	230	6.5	572	[illegible]2	[illegible]	[illegible].5	4.3	[illegible].03	12[illegible]	64[illegible]	[illegible].87	---	24	[illegible]	2[illegible]	9[illegible]	[illegible].
W-1	Irrig.well	7/19/74	13.5	--	1.6	24[illegible]	10[illegible]	180	11	487	130[illegible]	34	[illegible].6	[illegible].01	[illegible].09	250	221[illegible]	3.01	---	1400	980	2.1	[illegible]2800	7.4
W-2	do	7/13/74	10[illegible]	1.8	9.9	10[illegible]	75	35	6.9	367	310	5.6	[illegible].5	[illegible].00	[illegible].00	12[illegible]	727	.99	3.53	560	260	0.6	[illegible]1050	7.3
SURFACE WATER Site																								
S-2	Stream	7/13/74	22	.11	11	44	57	11	6.8	265	13[illegible]	4.4	.4	[illegible].00	[illegible].00	10[illegible]	395	.54	.12	340	13[illegible]	0.3	62[illegible]	[illegible].7
W-2	do	11/13/74	3	.25	6.7	5[illegible]	42	7.5	4.6	293	9[illegible]	3.4	.4	.16	[illegible].06	8[illegible]	35[illegible]	.49	---	320	77	0.2	63[illegible]	7.3
D-1	do	7/15/74	19.5	16.2	19	11[illegible]	78	31	14	501	27[illegible]	13	.5	[illegible].03	.12	31[illegible]	782	1.06	33.8	600	180	0.6	125[illegible]	7.[illegible]
D-1	do	7/17/74	22	.32	9.9	47	50	12	6.4	267	[illegible]2[illegible]	4.1	.4	.07	.03	13[illegible]	375	.51	.32	310	87	0.3	60[illegible]	6.6
D-1	do	11/13/74	5	.25	6.2	5[illegible]	46	12	5.1	275	11[illegible]	4.[illegible]	.4	.01	[illegible].03	8[illegible]	37[illegible]	.51	---	330	11[illegible]	0.3	65[illegible]	7.7
T-2	do	7/13/74	34	.16	11	[illegible]13	14[illegible]	77	11	310	75[illegible]	1[illegible]	.3	.23	[illegible].03	14[illegible]	13[illegible]	1.77	.56	900	65[illegible]	[illegible].3	165[illegible]	[illegible].4
T-4	do	7/15/74	--	4.[illegible]2	11[illegible]	22[illegible]	7[illegible]	55	1[illegible]	280	79[illegible]	11	.4	.19	.12	30[illegible]	1260	1.71	136.	87[illegible]	64.	[illegible].5	179[illegible]	[illegible].
T-4	do	11/13/74	25	.67	11	56	12.	[illegible]5	23	236	110[illegible]	18	.5	.51	[illegible].03	24[illegible]	174[illegible]	2.37	3.15	110[illegible]	25[illegible]	1.[illegible]	216[illegible]	6.[illegible]
T-4	do	7/13/74	12	.11	1[illegible]	14	16	11	1[illegible]	266	5[illegible]	23	.4	[illegible].03	[illegible].00	17[illegible]	1300	2.04	.77	1000	79[illegible]	1.[illegible]	1395	7.7
T-4	do	7/13/74	[illegible]	[illegible].1	[illegible]	4[illegible]	12	4	7.	371	[illegible]4	[illegible]	[illegible].5	[illegible].15	[illegible].06	13[illegible]	125[illegible]	[illegible].77	---	84[illegible]	540	1.3	1800	7.7

2. Skutumpah Creek

Skutumpah Creek flows south through the eastern part of the study area. It is formed by the confluence of Mill and Tenny Creeks in the northern part of the area, both of which are spring fed. Only Mill Creek is perennial. Tenny Creek was dry at the confluence during the study period except for periods following heavy rainfall. Mill Creek and Skutumpah Creek were therefore considered in this study to be a single stream traversing the area.

The Mill Creek-Skutumpah Creek channel is characterized by vertical banks and a wide streambed in which the normally small stream meanders. The streambed north of the study area is mostly composed of gravel washed from the Wasatch formation about 3-1/2 miles upstream. Amount of gravel in the streambed decreases progressively downstream, with little reaching the southern edge of the study area. No coal outcrops were observed in the streambed.

Three surface-water data sites were established on the stream. A staff gage and automatic sediment sampler were established at site S-1, but were destroyed by the July 20 flood. The gages were not reestablished. Site locations are shown on Figure 15 with discharge and sediment data shown on Table 25.

Normal streamflow progressively decreased downstream during most of the study period. Flows shown on Table 25 for sites M-1, M-2, and S-1 indicate that half or more of the normal flow seeped into the ground between M-1 and M-2 and the remainder seeped into the ground between M-2 and S-1. The amount of sediment in the water during normal flow was small and the water appeared clear. Floods, however, carried large amounts of sediment as indicated by the data collected at site S-3 on July 15. Appearance of the floodwater was medium to dark brown. High watermarks of July 20 were the highest observed in the drainage. No high watermarks from previous years showed above this.

All flow seeped into the ground near the northern edge of the study area after July floods receded. Water again flowed in the channel when floods occurring in October receded. A local rancher reported that this phenomenon occurs with flooding, but that during 1973 when no floods occurred, water flowed through the channel during the entire year. Possible reason for these occurrences is that

some floods wash fine particles from the streambed allowing seepage to occur, while other floods deposit fine particles to plug the seepage spaces.

Channel width and high watermarks north of site M-1 suggest that more water flows in this area than farther south during floods. Progressive decrease toward the south is attributed to underground seepage. Amount and extent of the seepage should be investigated in future studies.

Water in Skutumpah Creek is used for irrigation beginning about two miles south of the study area when water flows that far. When the water seeps into the ground, it probably adds to ground water of the irrigated area and is subsequently pumped for irrigation.

Total annual flow of 350 acre-feet at site S-1 was estimated by channel geometry.

Table 26 shows the chemical quality of water at sites M-2 and S-1 below the study area. Analysis of water from M-2 and the November analysis from S-1 are similar for most constituents. Water collected during the flood of July 15 showed larger values for all constituents than did water collected during periods of normal flow. Values of all constituents decreased after the flood receded and while flow conditions were still unstable (July 17). The pH was lower during flooding than during normal flow, but was still lower two days after the flood receded.

3. Intermediate Drainage

A relatively large ephemeral drainage exists between Thompson Creek and Skutumpah Creek. One data site was established on this drainage (Figure 15). For accessibility, the site was established nearly two miles below the study area.

Flow in this ephemeral drainage results only from storms or possibly from spring snowmelt. Estimated flows and results of sediment sampling are shown on Table 25. Three of the four sediment samples were collected with an automatic sediment sampler. These samplers indicate significant amounts of sediment are moved when flow does occur in this drainage.

Total annual flow of 5 acre-feet was estimated by channel geometry. No chemical quality samples were collected at this site.

4. Combined Drainage

Thompson Creek and the intermediate drainage join Skutumpah Creek about three miles south of the study area. Flow from the combined drainage is directed thence into the Johnson Wash, Kanab Creek, and the Colorado River. It is possible, therefore, that floods originating in or near the study area could reach the Colorado River. Floodwater with increased sediment loads and concentration of total dissolved solids caused by disturbed or stripped areas could affect surface-water systems and ground-water aquifers of numerous farms and ranches between the study area and the Colorado River, as well as affecting the quality of Colorado River water. Water from July floods was observed in Johnson Wash more than 20 miles below the study area, but it is not known how much farther the water progressed.

No data are available concerning possible increases in sediment loads that might be caused by mining. Studies in strip-mined areas of Kentucky, however, show that chemical degradation was about 12 times faster and sediment loads were as much as 1,000 times larger in stripped areas than in unstripped areas (Collier, 1970, pages C30, C45, and C46). Mining operations in the study area should be designed to prevent such increased stream loads from leaving mine areas.

Normal flow is probably too small to be of value in mining operations. Runoff from snowmelt may significantly increase the flow during spring months, but data should be collected during that period to determine whether or not the flow would be of value.

No fish or visible aquatic life were observed in any of the sites where data were collected.

Inplace and composite streambed samples were taken after the July floods at sites T-4 and S-1. The samples were stored for comparison with future streambed samples.

D. Ground Water

Ground water occurs in and near the study area although the characteristics of the aquifer remain mostly unknown because of insufficient data. No wells existed in the study area prior to beginning the project; consequently, ground-water data

were unavailable until the latter part of the study period when wells were completed. No springs were found in the study area, but several springs exist in the Thompson Creek and Skutumpah Creek drainages above the study area, (Goode, 1966, pages 17 and 18).

1. Bureau of Reclamation Drill Holes

Five core holes were drilled by the Bureau of Reclamation during the study period. Three of these holes were cased with 2-inch pipe for observation wells. Hole locations, designated DH-101, DH-104, and DH-105 are shown on Figure 15. Drill Holes 101 and 105 were drilled through the top layer of coal only, whereas DH-104 was drilled through a second layer approximately 160 feet below the top layer (Table 27).

Data concerning these holes and depths to water following water stabilization from drilling are shown on Table 27. Depths to water show that the water surface is above the top of the coal in DH-101 and DH-105, and above the bottom layer of coal in DH-104. Change in water level in DH-101 from September to October could be caused by an unstabilized condition from drilling, or it could be fluctuation resulting from seepage trends along Skutumpah Creek. A longer period of record for both surface and ground water would give a more accurate indication of fluctuation or interaction.

2. Irrigation Wells

Two irrigation wells exist about two miles south of the study area (Figure 15). Well W-2, on the Skutumpah drainage, is a replacement for well (C-40-4-1/2) 32bab-1 (Goode, 1964, pages 45 and 47), and well W-1 on Thompson Creek drainage was drilled in September 1974. Depth-to-water records during the study period for both wells are shown on Table 27.

3. Utah International Inc. Drill Holes

Utah International Inc. drilled numerous holes in and near the study area. Some of the holes contained water, but many of them were dry and none were cased. Depth-to-water data in the holes containing water were approximate because of a short stabilization period following drilling, and possible caving of the holes before water stabilized. Locations of ten holes that contained water in and near the study area are shown on Figure 15.

Table 27.--Depth to water below land surface in two wells and three drill holes.

Well No.	Depth	Date	Depth to Water	Remarks
DH 101	235	9/18/74	182.76	Coal from 199.7 to
		10/16/74	188.60	218.4
		11/13/74	188.27	
DH 104	306	10/16/74	224.76	Coal from 80.5 to 97.8,
				261.3 to 269.1
DH 105	205.5	10/16/74	150.52	Coal from 169.2 to 189.6
W-1	150	10/17/74	15.15	Drilled Sept., 1974
		11/13/74	14.34	
W-2	--	7/18/74	32.74	
		8/12/74	32.24	
		9/18/74	32.72	
		10/16/74	32.10	
		11/13/74	31.90	

4. Potentiometric Surface

Severe block faulting has occurred in the entire area according to recent geologic maps (Goode, 1973) and data from Utah International Inc. (Figure 15). Water surface throughout the area is discontinuous as a result, and water levels from the 15 wells were insufficient to define this surface. Water-surface altitudes are shown on Figure 15 for each well. These altitudes show that ground-water movement is toward the south and that the gradient is steep. It is assumed that the water table in the faulted areas where there were no data is similar to the areas where there were data available.

No data are available on the influence of mining on the ground-water aquifer. The aquifer would be disturbed by mining, though, because at least part of it is formed by the coal layer. It would be unlikely that during reclamation a material with the same recharge characteristics would replace the present aquifer. Flow through the new material would probably be at a different rate than in the undisturbed aquifer to the north and south of the mined area. This could result in changes in the water table characteristics in and south of the mined area after reclamation. A series of observation wells should be drilled above, below, and in the study area in order to establish ground-water characteristics before mining begins.

5. Aquifer Tests

Pumping tests were attempted on DH-101, DH-104, and DH-105 shortly after completion of the wells. All water was pumped from the casings within seconds after pumping started, and inflow was not sufficient to allow additional water to be pumped. Later a slug test (Ferris, 1962, pages 104 and 105) was made at each well, but results were inconclusive. The results of these attempts suggest, however, that transmissivity of the aquifer is low.

Results of a properly designed and conducted aquifer test would probably apply only to a small area because of faulting. Tests should be run in several of the faulted areas to obtain representative results for the entire area, and to determine if aquifer characteristics of small areas are similar.

6. Chemical Quality

Analyses of water from DH-101, DH-105, irrigation wells W-1 and W-2, and some surface-water sites are shown on Table 26. Sufficient water could not be pumped from DH-104 to obtain a sample. Water in DH-101 had more than three times the concentration of total dissolved solids of water in DH-105. Conversely, water in irrigation well W-2, in the same drainage as DH-101, had more than three times the concentration of total dissolved solids of water in well W-1, in the same drainage as DH-105.

Water in DH-101 had nearly three times the concentration of total dissolved solids of surface water in Skutumpah Creek, indicating that the quality is probably affected within the aquifer around DH-101. Conversely, water in DH-105 had less than half the concentration of total dissolved solids of surface water in Thompson Creek. This may be caused by the lack of surface water seeping into the aquifer in Thompson Creek drainage, where channel and banks are mostly clay.

E. Conclusions

Conclusions from this study are necessarily general because of the short study period, and may serve best as guides to future studies. Data collected were indigenous to this short period only, and should not be extrapolated to other periods.

Sufficient data were collected to show that localized precipitation patterns are different, although annual precipitation may be similar. Intense thunderstorms occur and cause a high rate of runoff, although the total amount of precipitation may be small.

Normally streams are small and water is clear. Flooding that occurs as the result of thunderstorms carries large quantities of sediment. Sediment carried by floods would probably be significantly increased if soil conditions were disturbed by mining without adequate flood protection.

The concentration of total dissolved solids in surface water increases during floods. Flooding over disturbed soil areas during mining could further change the water quality. Increased sediment loads and chemical quality changes could have adverse effects on surface and ground-water conditions from the mined area to the Colorado River.

Ground water exists in much of the study area at depths above the coal surface. Potentiometric surface could not be defined because of extreme faulting and insufficient data. Direction of flow was determined to be toward the south, and transmissivity is low. Ground water is probably affected by surface-water seepage in Skutumpah Creek drainage, but may not be significantly affected by surface-water seepage in Thompson Creek drainage.

Chemical quality of the ground water is different in the two main drainages of the study area. Water from DH-101 in the Skutumpah Creek has more than three times the concentration of total dissolved solids of water from DH-105 in the Thompson Creek drainage. Difference in quality could be from interaction with surface water and chemical characteristics of the aquifers. These analyses may represent conditions near the wells only because of faulting throughout the area.

Amount of available water is probably not sufficient for mining operations. More data should be collected, particularly for ground water, to determine more accurately the water available.

F. Recommendations

A continuing program to collect data should be implemented as soon as possible to establish hydrologic conditions prior to mining. The continuing program should follow the pattern of this preliminary study, but with permanent data-collection stations and more observation wells. Permanent stations should be established on Thompson Creek and Skutumpah Creek above and below the study area to collect discharge, sediment, chemical quality, and aquatic life data. Observation wells, some equipped with water-level recorders, should be placed above, in, and below the study area to monitor ground-water fluctuations.

Data from stations and wells above and below the study area would establish a hydrologic base before mining starts. Stations above the study area would continue to give equivalent data after mining begins, and stations below the area would show changes caused by mining.

At least one well in the study area should be designed for pump tests. Faulting in the area should be considered in locating this well and the observation wells.

Recording rain gages should be established to monitor frequency and intensity of precipitation on the area.

A skeleton form of this program should be established throughout the remainder of the lease area to relate conditions over the entire area to the intense study of the smaller control area. The entire program should be coordinated with Utah International Inc. so that data collection is not duplicated.

Mining operations should be designed so that flow in the drainage is essentially undisturbed. Provisions should be made in major drainages for allowing the flow, especially during floods, to pass through the mined area without accumulating significant amounts of sediment. Possible methods of accomplishing this include: not mining the drainages, fluming a stream across a stripped area, or building settling ponds below the mined area to contain floodwater and allow sediment to settle as water is released at an equalized rate. The third method has the advantage of accumulating soil, much of which would be topsoil, that could be used to rehabilitate the area. Water released from such a system would contain less sediment than typical floodflow, may contain a lower concentration of dissolved solids, and released in manageable quantities would conceivably be of more use to downstream users.

VI. SEDIMENT YIELDS AND FLOOD DISCHARGES

VI. SEDIMENT YIELDS AND FLOOD DISCHARGES

The baseline information on sediment yields and flood-peak discharges included in this section was prepared for use by all concerned with the leasing, strip surface mining, and rehabilitation of coal lands in the Skutumpah Creek and Thompson Creek Basins in Kane County, Utah. The sediment yield estimates were derived using a qualitative rating method. They were not verified by actual measurements, but appear to be reasonably accurate, based on meager sediment yield data in the neighboring Sheep Creek and Paria River Basins.

A. Methods

The method used to obtain the source-area sediment yield estimate shown on Drawing No. 1224-0A-300-48 was the Pacific Southwest Interagency Committee (PSIAC)(1968) method which entails the rating of nine factors: surface geology, soils, climate, runoff, topography, ground cover, land use, upland erosion, and channel erosion and sediment transport. While the method was developed to make broad sediment yield classifications for large areas, such as river subbasins, Shown (1970) found that the method provides reasonable estimates for drainage areas as small as one-tenth of a square mile.

Source-area sediment yield estimates were actually made on 15 relatively homogeneous small watershed areas within the area shown on Drawing No. 1224-0A-300-48 Aerial photographs (1:12,000 scale) furnished by the U.S. Bureau of Reclamation were then used to extend the estimates to the entire mapped area. Systematic interpretation of the photographs included consideration of (1) vegetation type, (2) density of the vegetation, (3) landform type, (4) steepness and length of the slopes, and (5) drainage density. Categories 2, 4, and 5 were rated on a relative basis within the mapped area on a scale ranging from 0 to 3, which corresponds to none, low, medium, and high.

The basin sediment yields shown in Table 28 for drainage basins B, C, D, F, G, and I were computed by multiplying the area-weighted source-area sediment yield for each basin by a sediment delivery ratio. The sediment delivery ratio is the fraction of source-area sediment that is delivered at some downstream point in an integrated drainage network. A rating scheme developed by Frickel, Shown

Table 28.--Sediment yields and channel characteristics at selected sites on the Alton, Utah EMRIA Study Site

Basin[1/]	Drainage area (mi^2)	Annual weighted source-area sediment yield (acre ft/mi^2)[2/]	Sediment delivery ratio[2/]	Annual basin sediment yield (acre-ft/mi^2)	Channel characteristics at basin outlet			
					Form	Bed material	Bank material	Gradient (percent)
A	10.1	-	-	.9	Raw, deep, steep-banked gully	Sand, gravel, little clay	Sandy clay	1.5
B	.11	1.02	.75	.8	Mature gully with flood plain	Clay, few cobbles	Sandy clay	1.5
C	1.02	.35	.60	.2	Raw, deep gully with steep sloughing banks and gravel bar	Sand, gravel	Sandy clay	3
D	.11	.36	.70	.3	Small gully, flows very infrequently	Gravel, sand, clay	Sand, clay	1.5
E	5.6	-	-	1.1	Flood-ravaged channel choked with unstable sediment	Sand, gravel, cobble, boulders	Alluvial gravel	3.5
F	.07	1.23	.80	1.0	Gully with steep banks, sparse shrubs on flood plain	Sand with clay skin	Sand, gravel	1.0
G	.67	.41	.70	.3	Deep gully with sloughing bank on one side and vegetated flood plain on the other side	Sand, gravel, cobble	fine gravel	2.0
H	16.7	-	-	1.2	Moderately deep gully with steep bank on one side and vegetated flood plain on the other side	Unstable sand, gravel and cobble bar deposits	Sand and gravel	1.0
I	2.53	.42	.70	.3	Gully with gentle banks, appears to be filling up with sediment	Sand, gravel	Fine sand	1.0
J	20.4	-	-	1.0	Moderately deep gully with vegetated flood plain	Sand, gravel, cobble and armored mudballs	Sandy clay	1.0

[1/] Locations of the basin outlets are shown on plate .

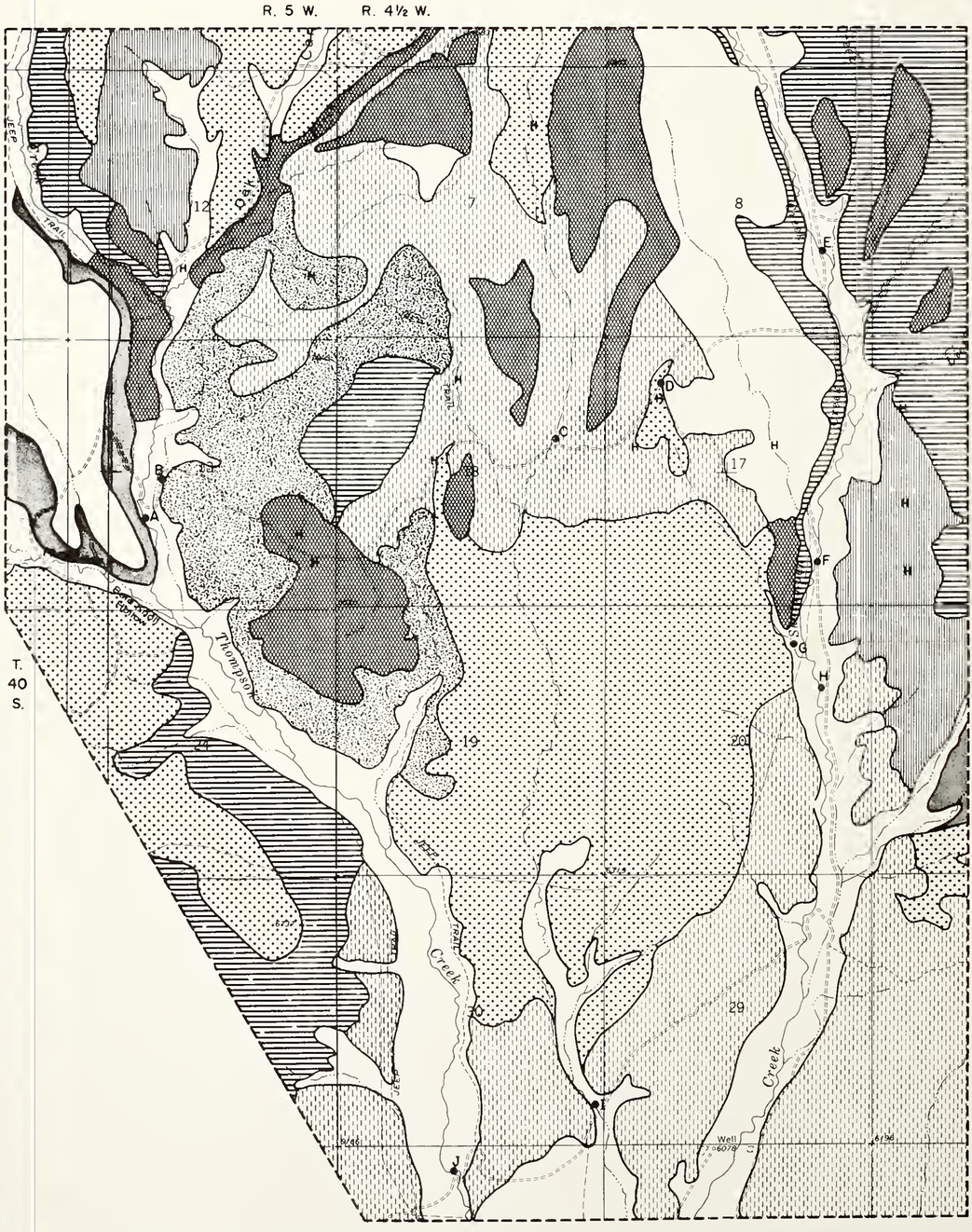
[2/] The unmodified PSIAC method, which takes into account the source-area sediment yield and sediment transport factors, was used to get the basin sediment yields at sites where no values are given.

EXPLANATION

Annual source-area sediment yields (acre-ft/mi²)		Topography	Slope: Range percent	Slope: Mean percent	Relative drainage density	Surficial materials
.1- .3	a.	Pediments	4- 8	5	Low	Stony soils developed in outwash deposits
	b.	Mesas	4- 8	5	Low	Sandy and clayey soils
	c.	Revegetated bottomlands	4	4	Low	Coarse- to medium-textured alluvium
.2- .4	a.	Bottomlands	2- 4	3	Low	Coarse- to medium-textured alluvium
	b.	Dissected pediments and mesas	3-15	7	Low to medium	Sand and clayey soils, some clinker
.3- .5	a.	Hill-and-valley	8-33	18	Low to medium	Sandy, silty and clayey soils, some clinker
	b.	Hillslopes	7- 9	8	Low	Sandy and silty soils
.4- .6	a.	Hill-and-valley	8-50	21	Low to medium	Sandy, silty and clayey soils
	b.	Hummocky	22-33	25	Medium	Clinker, sandy and clayey soils
	c.	Upland alluvial	8-17	12	Medium	Sandy clay soils
.6- .8	a.	Hill-and-valley	11-40	22	Medium to high	Sandy and clayey soils
.8-1.0	a.	Steep valley-side slopes	36-40	38	Medium	Clayey- and medium-textured soils
1.0-1.2	a.	Steep hill-and-valley	20-50	35	Medium to high	Clayey and sandy soils
1.2-1.5	a.	Steep hill-and-valley, few landslides	8-55	35	High	Sandy and silty soils

●A Locations of the outlet of drainage basins for which sediment-yield estimates were made and the points at which peak flow estimates were made.

H Locations of headcuts in channels.



Base from U.S. Geological Survey
Bald Knoll and Skutumpah Creek 7½ minute Quadrangles

1000 0 1000 2000 FEET

Plate

Estimated source-area sediment yields, locations of points on channels to which basin sediment yields apply and where peak discharge estimates were made, and locations of headcuts on the Alton Coal Field Study Site, Utah

1224-0A-300-48

and Patton (1975), which utilizes point observations in the field and interpretation of aerial photographs, was used to obtain the sediment delivery ratios. The scheme considers the effects of various channel conditions on sediment delivery by perennial and ephemeral streams. Conditions considered were: (1) channel width and gradient, (2) whether the channel is gullied or is a broad, grassy drainageway, (3) the size of the bed material and vegetative cover on the bed, (4) intermittent gullies in the channel system, and (5) evidence of deposition, such as channel deposits, the occurrence of alluvial fans, and deposition on bottom lands where flows spread either naturally or because of manmade impoundments or diversions of water.

A channel geometry method was used to obtain the estimates of flood-peak discharges for the lettered locations shown on Drawing No. 1224-0A-300-48 which are on ephemeral streams. Sixteen years of record of the annual peak flows for five crest-stage gages on ephemeral streams in southwestern Utah and two crest-stage gages in northwestern Arizona were used to establish the relations of peak flows to the width and the depth of the active channels. The active channel is the lower portion of the channel entrenchment which is actively involved in the transportation of water and sediment during the usual regime of a stream (E. R. Hedman and W. M. Kastner, written communication, 1974). The reference level used in measuring the geometry of the active channel is where the banks or point bars abruptly change to a flatter slope. Above this level permanent vegetation is usually present. The vegetation is used to determine the reference point in the absence of an abrupt slope break, which is often the case in small ephemeral channels.

The prediction equations that resulted from the analysis of the crest-stage gage data and which were used to make the peak discharge estimates for the site are of the form: $Q_{RI} = a\ W^x D^y$ where Q_{RI} = peak discharge for a given recurrence interval, a = regression constant, W = active channel width, D = mean depth of the active channel, and x and y are regression coefficients.

B. Results

1. Sediment Yields

The conditions in this part of Utah are such that high sediment yields are expected. Some of the more pertinent conditions are as follows: (1) there is a

relatively high frequency of intense thunderstorms, (2) the area tends to be composed of steep hillslopes and narrow valleys, (3) the channel gradients are relatively steep, (4) many of the soils are inherently erodible, particularly those developed from Tropic shale and from Winsor member of the Carmel formation, and (5) the lack of vegetal understory in the pinyon-juniper and sagebrush types.

There are, however, surficial materials in parts of the area that modify overland flow and reduce erosion such that sediment yields from these areas are only low to moderate. The veneer of pediment gravels overlying the Tropic shale on sec. 8, T. 40 S., R. W4-1/2, and the west part of sec. 13, T. 40 S., R. 5 W. armors the surface, retards overland flow, and thus greatly reduces erosion. The clinker fragments that overlay a considerable area in secs. 17-20, T. 40 S., R. W4-1/2, and sec. 24, T. 40 S., R. 5 W. have an even greater effect in reducing erosion. If mining occurs and if these or similar materials are not placed back on the surface, erosion will be significantly increased, particularly prior to the time when vegetation becomes well established.

The present upland drainages, even on the pediments and mesas, tend to be deeply incised channels in narrow valleys. In these drainages, soil and rock slough and creep directly into the channels from the steep slopes above the channels. This is a significant source of sediment because this material is swept from these channels during flows.

When an area such as this is regraded after it has been mined, sediment yield would be less if the broad drainage valleys are designed into the reconstructed landscape. Contour furrowing of the overburden will decrease runoff and help prevent gullying of the drainageways. If gullying, however, does occur in a broad valley, steep slopes will be intercepted only at points where the channel meanders to the side of the drainageway.

A reservoir constructed in 1954 about 5 miles west of the study area at the mouth of a 0.01 square-mile watershed was augered to determine how much sediment had been deposited in it. The average annual sediment yield of the watershed was computed to be 1.45 acre-feet per square mile. The watershed is

steep, is mantled with sandy, noncohesive soils and has a moderate cover of pinyon-juniper. These conditions should result in a sediment yield which is in the upper part of the range of sediment yields for the area.

In view of this, the sediment yield estimates for the steeper watershed such as A, B, E, F, and H seem reasonable. The sediment yield of these watersheds should be less than that of the measured watershed because they are not as steep and some of them have considerably larger drainage areas which result in lower sediment yields per square mile.

Many of the channels on the study area are raw gullies and thus sediment delivery in them is rather efficient. However, a number of headcuts were identified during the air-photo interpretation and are indicated on Drawing No. 1224-0A-300-48 by "H". Sediment transport tends to be less efficient in the vegetated channels above the headcuts. The rate of headward movement of these headcuts is unknown, but it is probably slow. This means that sediment contribution from gully erosion is small in this area.

Presuming that the area will be surface mined, some estimates of sediment yield from the overburden areas were made during several phases of rehabilitation and under assumed slope and cover conditions (see Table 29). On most of the area there is sufficient soil to stockpile for later placement on the overburden for seedbed. However, many of the soils are fine-textured and much of the overburden underlying it will be derived from shale bedrock. A mechanical treatment such as contour furrowing (Branson, Miller, and McQueen, 1966) or gouger pitting (Sindelar, Hadder, and Majerus, M.E., 1973) would reduce runoff and erosion and enhance the establishment of vegetation on this type of material.

Even with mechanical treatments there probably will be times when there will be some sediment-laden runoff from the overburden areas. This could happen before the overburden is graded and mechanically treated or as a result of repeated intense storms after the area is graded, mechanically treated and seeded, but before soil structure has been reestablished and the vegetal cover has been established.

Increased sediment yields from the area also will occur if additional water is introduced into the channel because of diversions around the mine, runoff from mine roads or possbile dewatering of the mine. This additional water would cause

Table 29.--Estimates of annual sediment yield from presumed overburden areas before, during and after rehabilitation for various rock types, slope gradients and amounts of bare soil

	Ungraded overburden banks	Graded overburden			Rehabilitated overburden during establishment of perennial vegetation[1/]			Rehabilitated overburden after establishment of vegetation[2/]		
Slope (percent)	80-100	0-5	15	30	0-5	15	30	0-5	15	30
Bare soil (percent)										
shale material	100	100			50	60	70	30	40	50
sandstone and shale material	75 (rock,25)	75 (rock,25)			25	35	45	15	25	35
Sediment yield (acre-ft/mi^2)										
shale material	2.5-5.0	.3	.5	.9	.2	.3	.5	.2	.3	.5
sandstone and shale material	1.5-2.0	.2	.3	.6	0	.2	.3	.1	.2	.4

1/Assumed that overburden would be contour furrowed or pitted to reduce runoff and erosion and enhance establishment of the seeded perennial grasses and shrubs. Assumed that the area would be protected from grazing during this 5-year rehabilitation period.

2/Moderate intensity grazing was assumed when making these estimates.

erosion of the channel banks and bed, particularly if the water is introduced more-or-less continuously into a channel that was formerly dry most of the time. Saturated alluvium is much more erodible during flash floods than dry alluvium.

In the development of the complete mine system in this area, there is some opportunity to capitalize on the probable increased sediment loads as well as on the normal sediment loads downstream from the mine. Anywhere that a mine road crosses a stream a sediment barrier could be designed into the fill. The essential feature would be to raise the base level of the stream up to at least the level of the lowest terrace by means of a competent bedrock spillway or a concrete spillway. A reservoir with a drop pipe to let the water out would provide a suitable sediment barrier for the smaller channels. These barriers would cause the flows to widen and slow down, and thus drop part of their sediment loads and fill the gullies progressively upstream as was reported by Hadley (1965) in a study in northeastern Arizona. The ground-water levels in the alluvium should rise because of the barriers. This and the flooding of the terraces will make the bottom lands upstream from the barriers a favorable habitat for productive forage species such as alkali sacaton (Sporobolus airoides).

2. Peak Flows

Estimates of peak discharges for five recurrence intervals and the width and depth of the active channels are listed in Table 30 for the lettered locations shown in Drawing No. 1224-0A-300-48. Annual peak flows in this area usually occur as a result of intense thunderstorms in July, August, or September. However, given unusual circumstances of a heavy snowpack and rapid melting, rather large peak discharges may occur during late winter or spring.

The relations of channel widths and depths to peak discharges were developed from available crest-stage gage data. The standard errors of estimate of the 2-, 5-, 10-, 25-, and 50-year flood peaks were 47, 24, 33, 54, and 85 percent, respectively. A standard error of "x" percent indicates that two-thirds of the sample values fall within + x percent of the regression relation. These standard errors, with the possible exception of the one for the 50-year flood are about normal for channel geometry relations and indicate that reasonably reliable estimates can be made with the relations.

Table 30.--Channel measurements and estimated peak discharges for given recurrence intervals on the Alton, Utah EMRIA Study Site

Basin	Dimensions of active channel		Estimated peak discharge (ft^3/s)				
	Width (ft)	Mean Depth (ft)	2 yr	5 yr	10 yr	25 yr	50 yr
A	17.7	1.3	117	588	923	1,330	1,780
B	5.4	.3	1.1	30	52	72	99
C	7.5	4.3	3.1	57	96	135	184
D	3.0	.3	.2	13	19	27	38
E	17.0	1.1	50	332	530	762	1,020
F	4.0	.4	.5	19	34	46	65
G	4.7	.4	.8	27	46	63	88
H	33	.7	234	753	1,157	1,707	2,216
I	10.4	.25	5.3	72	119	169	227
J	53	2.1	1,660	2,810	4,190	6,260	8,030

VII. LEGAL REQUIREMENTS

VII. LEGAL REQUIREMENTS

There is no Federal or State legislation regulating the reclamation of surface mined areas in Utah.

VIII. ALTERNATIVE METHODS OF RECLAMATION

VIII. ALTERNATIVE METHODS OF RECLAMATION

A. Objective of Reclamation

The primary objective during and following the surface mining operation is the protection of the land and water resources during mining and the reclamation of the area in as short a period as practical when mining is concluded. There are usually several options available to meet these objectives. These need to be flexible enough that the mining company, after conclusion of site studies, can select options that are most economical, while fulfilling the company's protection and reclamation obligations. The available options vary with physical characteristics of the area, and therefore, the plan must be tailored to specific site conditions. There also would need to be some minimum standards set forth to the company so that they are informed as to what the reclamation plan must accomplish. These standards should set forth requirements for: (1) protection of surface and ground-water supplies from deterioration in quality, (2) protection of the soils from erosion, (3) final configuration of the area, (4) revegetation criteria, (5) maximum time limit to accomplish reclamation, and (6) management and monitoring.

B. Evaluation of Soils and Overburden Materials as Plant Growth Media

The suitability of the study site soils, as plant growth media, varies considerably. The soils were grouped into categories of soil associations which reflect their suitability as plant growth media. The occurrence of these soil associations in the project area is shown on the drawing entitled Alton Coal Field Soil Associations following page 10 .

1. Soil Associations 4001, 4002, 4005, 4006, 4008, and 4013

These soil profiles are excellent as plant growth media and free of chemical toxicity. They represent 31 percent of the study area. Areas of heavy gravel, cobble, and stone concentrations should be excluded from stockpiling operations.

2. Soil Association 4003

This soil association represents nine percent of the study area. It is marginal for the reestablishment of vegetation. Inplace, these soils support a thick sagebrush stand. Laboratory studies show these soils to be very fine-textured. Water movement through fractured samples is very slow. Salt concentrations are very low to depths

of about five feet. Below five feet, moderate salt concentrations are found, which would require their being leached prior to successfully establishing certain plants.

3. Soil Association 4017

This soil association represents 17 percent of the study area. It is unsuited as a plant growth media. It has a very shallow surface soil overlying a slightly weathered shale to about 36 inches. Underlying this is shale.

The thin surface soil would provide a marginal source of plant growth media, but stockpiling would be difficult and expensive. The shale material below this thin mantle is unsuited as plant growth media.

4. Soil Association 4015

This soil association, which represents nine percent of the study area, is a marginal source of plant growth media because of the heavy surface concentration of gravel, cobble, and stone. Much of the area is underlain at shallow depths (10 to 20 inches) by a thick stratum of pediment gravels, cobble, and stone. Coarseness is this association's deficiency. It is free of toxic concentrations of soluble salts.

5. Soil Association 4007

This soil association represents 11 percent of the study area. The suitability of the surface 8 to 12 inches is an excellent plant growth media. Below this depth these materials are of marginal values as plant growth media.

6. Soil Associations 4009 and 4014

These soil associations are marginal but could be used selectively as plant growth media. They represent 13 percent of the study area. They are coarse because of the heavy concentrations of gravel, cobble, and stone on the surface and in the profile. The soil profile thickness is generally less than 30 inches overlying shale, in much of the area. The shale material is marginal for a topsoil material, and water-holding capacity is low.

7. Soil Associations 4004 and 4010

These soil associations are marginal for plant growth media but could be used selectively. They represent 10 percent of the study area. Soil textures range from fine to coarse. Gravel, cobble, and stone are found on the surface and distributed throughout the media. Toxic concentrations of soluble salts are not associated with

these materials to depths of five feet. Seedbed preparation and reduced water-holding capacity would be problems inherent in this media.

8. Overburden Suitability

Underlying the alluvial pediment, the overburden consists principally of shale. Strata of sandstone constitute a small percent of the total thickness. In general, these shales are fine-textured and have very unfavorable sodium to calcium-magnesium ratios, which contribute to extremely high settling volumes and poor water transmitting characteristics observed in laboratory studies. However, data from some relatively significant strata, including depths 65.0 to 90.8 feet in DH-105, Table 3, indicate this material could be used as plant growth media.

C. Water Supply

Though the hydrologic studies were not conclusive, it is probable that a source of irrigation water will be difficult to obtain. The most economical system will probably be a combination of surface and ground water collected and stored for later use. Trade-offs will probably be necessary between the risks incurred and the cost of the next increment of water supply. As discussed later, soil characteristics and slopes would determine priority of use for a limited water supply.

1. Surface Water

The hydrologic studies estimated the flow of Thompson Creek to average 850 acre-feet annually, and Skutumpah Creek to average 350 acre-feet annually. The flow is erratic and when available is used for irrigation in the valleys. It would be necessary to purchase or rent existing water rights before this surface water could be used for irrigation in the reclamation areas. If water right problems could be solved, it would be possible to intercept the intermittent flows of drainages crossing the stripped area and to convey this water to a constructed storage facility.

2. Ground Water

Though the aquifer tests in the study area were not conclusive, the opinion was that transmissibility was low, which would be expected from the characteristics of the material contained in these aquifers. A continuing data collection program will be implemented by the U.S. Geological Survey to better define hydrologic conditions.

A potential source of ground water would be mine drainage from adjacent surface mining operations. If sufficient water were encountered, it could be drained to a constructed reservoir area and stored for later irrigation use. The storage requirements would depend on the rate of drainage inflow. Provisions for the water storage area would be needed. This could be constructed during surface mining operations. An approximate 300-acre-foot storage facility would be desirable.

If additional tests prove favorable, wells could be drilled to supplement other water sources. If a water storage reservoir facility were constructed, the most economical and efficient system would be a constant rate of pumping to the storage facility.

D. General Reclamation Practices

The following reclamation practices are applicable to the study site:

1. Final Configuration of Area

The objective of the replacement of the overburden and reshaping of the topography should be the creation of final topography which will blend with the form of the adjoining undisturbed landscape and the reestablishment of a positive surface drainage pattern.

The existing topography of the study site is severe with steeply sloping hillsides, terraces, and alluvial valley drainages. Some slopes exceed 40 percent. The erosion hazard on the steeper slopes is severe.

Within the study area, the strippable coal (overburden -200 feet) lies in a strip of one-half to one mile in width. The average thickness of the coal is about 16 feet. Therefore, the average coal volume removed from the profile would not exceed 13 percent of the total volume. The amount of coal actually removed is small in comparison with the amount of overburden handled, and therefore, it is reasonable to expect that the topography of the area can be returned to near its original form.

Reshaping to conform to the original topography is not always the most desirable. It is often possible to reduce the steeper slopes. These slopes are usually of relatively short reach. Reduction of these slopes, where possible, would lessen the erosion hazard, increase the success potential of revegetation, and reduce the

operational problems. Surface mining should not be permitted on slopes exceeding 50 percent, unless the area is small and can be reshaped to slopes of 3:1 or less. As observed in the geologic studies the present natural slope of the material suitable for plant growth media ranges to slopes of 3:1. It would be desirable not to exceed this slope in the reshaped topography. Steeper slopes would be generally unstable presenting slide and greater erosion hazards. The natural slope of shale was observed to range to 2:1. Present eroded gullies should be reshaped with side slopes not to exceed 5:1. Flow retarding structures should be installed to reduce erosion in drainages and could be used to collect water for livestock and wildlife use. After reshaping, the remaining high wall should be sloped to a maximum of 45 degrees as a safety precaution and to facilitate wildlife movement. Except where corrective action is being taken, slopes should generally conform to the original contour.

2. Reconstructing the Soil Profile

The volume of soil material to five feet of depth, suitable for replacement on the surface of a surface mined area, varies greatly from area to area on the Alton study site. Soil material on 42 percent of the study area is well suited for reclamation use based on depth of material and other physical characteristics. Seventeen percent of the area is unsuited as a source of surface soil material. The remaining 41 percent of the area is of varying marginal suitability. A depth of suitable plant growth media of 18 inches is needed for successful revegetation of disturbed land. (C. Wayne Cook, Professor and Head Ranges Sciences, Colorado State University.)

Prior to mining, overburden material would be identified as suitable for one of three uses: (1) topsoil suitable for seed germination, (2) suitable as a plant growth media, but may be less desirable on the surface than other soil material (example: a well-developed "B" horizon as compared to a very favorable surface soil), and (3) material which has a very limited suitability as a plant growth media or is unsuitable (examples: shales that have extremely low hydraulic conductivities or the coarse materials characteristic of certain strata of the old pediment formation).

Handling and placement of the overburden would depend on which of the above three categories it fills. Materials in categories (1) and (2) would require careful identification, handling, and stockpiling. Category (3) materials would be used for backfilling, and therefore, would be excavated and placed as expeditiously as possible.

Soil material which is best suited for a seedbed [material in category (1)] occurs as a relatively thin mantle. It is identified as the "A" horizon in the soil profile description in Figure 2. Special care must be exercised in salvaging this material. Suitable equipment will be required. Material identified as category (2) should also be carefully segregated and placed to provide the necessary subsoil.

After the backfilled material from category (3) is in place and properly shaped and smoothed, category (2) material should be distributed evenly to a minimum depth of 12 inches. A minimum of six inches of topsoil of category (1) material should then be moved into place for seeding (C. Wayne Cook).

If toxic materials are encountered, they should be buried as deeply as possible in the backfill. Selected shale materials may be useful as a seal to keep them in place.

The reconstructed soil profile (material suitable as plant growth media) should have a minimum thickness of 18 inches. Preferably, the surface six inches would be medium-textured, have good water-holding and transmitting characteristics after being disturbed and would be free of toxic concentrations of soluble salts.

The subsoil, a minimum of 12 inches thick, should consist of medium or finer-textured material. It should have favorable water transmitting characteristics, good water-holding capacity, and be free of toxic concentrations of soluble salts. If excessive salt concentrations were present, they could be expected to be readily leached from this zone.

The above profile would be suitable for revegetation by several seeding methods. A minimum moisture-holding capacity of three inches should be attainable and the internal drainability of the reconstructed profile would be satisfactory for range plant growth.

3. Erosion Protection

As soon as the soil profile has been reconstructed, protecting it from erosion becomes very important. Rainfall is typically of the thundershower type, intense, and of short duration. Snowfall may melt between winter storms or during the first warm days in spring. Melting rates may exceed the soils intake rate. This problem is compounded if the ground is frozen.

Protection of these soils can best be accomplished by good stands of healthy vegetation prior to the thundershowers typically occurring in late summer and early fall.

If after seeding, germination is to be accomplished by rainfall, special practices to reduce erosion might include:

a. Mulching with woody material obtained from shredding the pinyon-juniper vegetation which is so plentiful in the area.

b. Mulching with various types of hydrocarbon type materials.

c. Mulching with straw or other similar type material.

Coupled with the above mulching practices, or separately, the area could be terraced in one or more of its variety of forms or contour basins constructed to collect and hold the water, thereby permitting time for the soil to absorb the moisture.

Erosion retarding structures should be placed in areas where runoff can be expected to occur. They may consist of bundles of brush anchored in place or similar types of temporary structures to retard erosion while vegetation is being reestablished.

In the presence of the fine-textured surface soils, additions such as gypsum can be helpful in maintaining the soils infiltration rate.

4. Protection of Surface and Ground-Water Supplies

The quality of surface and ground water flowing through or from the area must continue to be closely equilvalent to that occurring naturally for the protection of downstream interests. This will require the monitoring of surface flows prior to disturbance of the area for use as a base and then a monitoring during and after mining until the area has been judged restored. Ground-water

observation wells below the mining area would be desirable for the monitoring of ground water prior and during mining.

The action necessary to protect surface and ground water will depend on the topography, overburden material, drainage pattern, ground-water aquifers, and toxic materials present. Alluvial valley floors and stream channels should be preserved. The unconsolidated alluvial deposits are highly susceptible to erosion. The removal of alluvium lowers the water table and destroys the protective vegetation cover. The bottom armor and the hydraulic characteristics of the channel once altered could never be restored. Examples of channels to be preserved are Thompson and Skutumpah Creeks.

The disturbance of side drainages cannot be avoided. In some areas, intercepted ground water may be a disposal problem. The ruling standard will be to not deteriorate downstream water quality either surface or underground. There are several options available to accomplish the objective depending on site conditions:

a. The surface drainages can be intercepted above the area being mined and transported by pipeline or flume to a natural drainage course. A control structure would be necessary at the point of discharge to avoid damage and the discharge must not exceed the existing carrying capacity of the stream at the confluence. This option would avoid problems with downstream water rights. The U.S. Geological Survey rain gaging program to be initiated in fiscal year 1976 will provide data for the design of these facilities.

b. If the holders of downstream water rights can be satisfied, a storage reservoir area could be maintained within the mined area and the surface water either intercepted and conveyed to the reservoir or wellpoints installed, which will probably be necessary anyway for ground-water drainage in many areas, and the water pumped to the storage facility. Some of this water could be used for dust control, and if of acceptable quality, to irrigate the replacement vegetation. If the water picks up toxic materials in the disturbed area, the reservoir may need to be lined to avoid excessive percolation to the ground water. If of acceptable quality, the water could be pumped to a natural drainageway or if a natural recharge area was located, it could be allowed to percolate to the ground-water aquifer.

c. The spoil piles prior to reshaping should be designed so that precipitation falling on the area does not run off. Placing the spoil along the approximate contours would minimize runoff.

d. In some instances. it may be desirable to construct a settling pond with an overflow section on water courses receiving runoff with high sediment content from the disturbed area prior to its confluence with a main channel. This has some disadvantages, such as difficulties in locating an adequate site for the pond and disturbance of additional areas.

e. A final option to consider is to leave the area undisturbed or use another mining method. The overburden may be deep and the strippable resource limited. The cost of protection and restoration may be excessive so that some limited areas may not be economically viable to strip mine, and in some cases, other mining methods may be more suited to the condition.

5. Revegetation

The objectives of revegetation are to (1) minimize erosion, (2) provide a compatible esthetical pleasing landscape, (3) encourage the reestablishment of native fauna, and (4) provide for an economic return as rangeland.

The highly erodible soils and rather severe topography of the study area dictate that ground cover needs to be established as soon as possible after final rehabilitation grading. The hazards of depending on natural precipitation to occur in a timely manner need to be considered in relation to the costs and availability of water supply for application of supplemental water through sprinkler irrigation. The obligations of the mining company should not be terminated until vegetation is firmly established. The company will need to weigh the additional costs of sprinkler irrigation against the cost of maintenance of the area over a longer period of time, the costs of repairing erosion damage, reseeding requirements, and protection of downstream areas from damage originating on the mined area. It can be expected that the topographic features of gradient and exposure will also influence the successful revegetation. In the more marginal years, vegetation may be established on the more favorable sites, while on the poorer soils, steeper slopes and south and west facing slopes success would be more limited.

Irrigation of the newly seeded area would provide man with control of moisture, the greatest variable in this area to successfully establishing the type and quality of vegetation desired at the time it is most needed to reduce erosion to a minimum. Mulching should be employed with irrigation. Together, these practices would complement each other in producing the desired vegetation cover.

The preparation of a good seedbed is important for the successful establishment of vegetation. Water retention practices are especially important if natural precipitation is to be relied upon. These practices include mulches, selection of topsoil with adequate permeability, and shaping the earth surface into configurations designed to intercept and hold precipitation. Mulching is also effective in conserving soil moisture and breaking the impact of the raindrop, thus reducing compaction and maintaining soil structure, thereby insuring a greater infiltration rate.

Surface grading and contouring can best be accomplished on the backfill material prior to spreading the plant growth media (topsoil) evenly over the area. Any sculpturing of the relatively thin media should be avoided to insure successful revegetation.

Application of phosphate and nitrogen fertilizers in proper amounts would further insure rapid growth of healthy plants. Planting coated seed would provide the young seedling with an immediate nutrient source. The developing seedling requires moisture and nutrients to extend its root system in the soil and produce photosynthetic tissue for food manufacture. There is a close relationship between the benefits of nitrogen fertilizer and soil moisture. Care should be taken that a balance is obtained.

The planting procedure used should be the one that, if possible, places the seed at the proper depth and interval in the soil. Generally, drilling gives the best results and is recommended if the terrain allows operation of wheeled machinery.

Two methods of broadcasting are through the uses of (1) hydroseeders, which apply seed mixed in water, and (2) fan or air blast seeders. The seed should be covered with soil in some way if it is to germinate and become established. In broadcast seeding, frequent light irrigations can be of great value in germinating

and establishing the desired stand. Seed should be covered rather shallow for best results. If mulches are used in conjunction with broadcast seeding, best results can be obtained by broadcasting the seed, covering with soil, and then applying the mulch.

6. Irrigation

The most important limiting factor in successful revegetation of the strip mined land is moisture. The distribution of precipitation during the growing season is as important as the total amount. Assuring adequate moisture by supplementing natural precipitation with irrigation would help establish a stand of plants in a shorter period of time.

The economic viability of irrigation will depend largely on availability of a water supply of adequate quantity and acceptable quality within the proximity of the area being mined.

Precipitation records for the 15 years of 1956 through 1970 indicate that for about one-third of the years, two irrigations would be desirable during the months of August and September following seeding, and for the remaining two-thirds of the years, one irrigation would probably be adequate. Much the same pattern would occur in the spring following seeding, with two irrigations being desirable during June and July in one-third of the years and one irrigation being adequate the remaining two-thirds of the years. The early summer irrigations would complete the cycle and the equipment would be moved to the next rehabilitation site.

A full irrigation water application would average .64 acre-foot per acre annually, and for 400 acres would average 256 acre-feet annually. The irrigation application would vary between 200 and 400 acre-feet annually depending on natural precipitation. The total water application rate on 400 acres irrigated would require about 2,400 gallons per minute (5.5 ft^3/s) to complete the irrigation in a 12- to 14-day period.

If this quantity of water is not available, lesser quantities could be utilized but with an increase in risks. It would be most important to assure adequate moisture immediately following seeding. The steeper slopes should have first priority

for water with the southern and western exposures heading the list. If possible, drought conditions should be avoided going into the winter to minimize winter kill. During a drought year with a limited water supply, damage could be reduced by a timely and selective use of the water that is available.

There will be adequate time after initiation of mining operations to determine if irrigation is feasible. The most economical source of water would probably be mine drainage since this must be disposed of anyway. The more costly increments of ground-water development through the installation of wells could be added as experience dictates. Initially an experimental plot of about 50 acres on one of the more critical areas would provide valuable information on the benefits and costs of irrigation.

E. Management

Grazing management is a necessity during establishment of the vegetation. The new seeding must be protected from grazing for at least three growing seasons, and on the harsher sites, four or more growing seasons may be necessary. The young seedlings should not be grazed until they are firmly rooted. Adequate fencing will be required to prevent grazing by both livestock and wildlife during the establishment period.

Annual weeds present harmful competition to seeded perennial species during the first two to three seasons after planting. These weeds should be controlled through the use of selective herbicides during at least the first year of development.

If irrigation is used as an aid in establishing vegetation, it should be terminated about 15 to 18 months after seeding.

F. Potential Effects on Air, Water, Vegetation, and Fauna

Until vegetation is reestablished, the area will be subject to wind and water erosion. The proper placement of spoils would minimize erosion during mining operations. After the area is reshaped, mulching is most effective in reducing wind erosion during vegetative establishment.

Establishment of a good, healthy stand of vegetation on the reconstructed soil profile would minimize adverse effects on air, water, vegetation, and fauna.

Failure to secure a satisfactory vegetative cover as soon as possible after the seedbed is prepared could have disastrous repercussions on the resource. Wind storms would cause erosion, fill the air with clouds of dust which, in some cases, could cause danger to the lives and property of men working in the area. Water falling on the loose unprotected soil would cause sheet, rill and gullying erosion which could destroy the reconstructed profile and load the waters flowing from the area with large quantities of sediment. Vegetation, if sparse, would be torn from its place by the forces of erosion and fauna would be denied the food that would otherwise be available.

G. Needs for Special Treatment

While most of the restoration practices are applicable to the study area in general, it was found that there are particular needs related to soil texture, soil depth, slope drainage, erosion hazard, and permeability that are very site specific. To examine these problems, the study area was broken down into 18 units based on the occurrence of similar problems. These units are designated on Drawing No. 1224-0A-300-45.

1. Areas 1 and 18

a. Description

These areas consist of the alluvial flood plain areas of Thompson Creek on the west border of the study area on Skutumpah Creek on the eastern border. Thompson Creek joins Skutumpah outside the study area. Skutumpah Creek is tributary to Johnson Creek which is the main tributary of Kanab Creek. These creeks carry large floodflows, are a source of ground-water recharge, and are a source of irrigation water. Once disturbed, the bottom armor and hydraulic characteristics could never be restored with the result of accelerated erosion of the channel, alteration of floodflow characteristics, alteration of ground-water recharge areas, deterioration of downstream water quality, and damage to agricultural lands downstream due to increased sediment in floodflows and in the irrigation water supply.

b. Special Treatment

Protect main drainage channel from disturbance.

2. Area 2

a. Description

Limited area, steep slopes, shallow usable soil depths, very slow permeability, directly tributary to Thompson Creek, severe erosion hazard, deep overburden to coal over much of the area.

b. Special Treatment

Conditions do not warrant strip mining. Auger mine or leave undisturbed.

3. Area 3

a. Description

Steep slopes (greater than 40 percent), shallow usable soil depths, very slow permeability, severe erosion hazard, a major tributary drainage to Thompson Creek, slopes are predominantly south and west.

b. Special Treatment

(1) There is little opportunity to lessen the steepness of the slopes. Other erosion control and moisture conservation techniques will need the maximum application.

(2) A minimum of 18 inches of soil material needs to be hauled into this area. Area 4 would be a potential source of material.

(3) Dozer basins of about 25-feet long and 3-feet deep, and placed on a rough contour interval of about 30 feet to intercept moisture would help prevent erosion of steep slopes.

(4) Due to steepness of slopes area should be hydroseeded.

(5) This area should be first priority for sprinkler irrigation.

4. Area 4

a. Description

Steep slopes (25 to 40 percent) and small areas exceeding 40 percent predominantly facing south and west. Critical to severe erosion hazard. The area is similar to Area 3 except there is adequate top and subsoil on the site.

b. Special Treatment

(1) The two small areas of shallow soil shown as 4a could be provided soil material from the subsoil strata of the remaining area.

E. 1,790,000 E. 1,792,500 E. 1,795,000 E. 1,797,500 E. 1,800,000 E. 1,802,500 E. 1,805,000 E. 1,807,500 E. 1,810,500

R. 5 W. R. 4 1/2 W. R. 4 W.

T. 40 S.

N. 337,500 N. 335,000 N. 332,500 N. 330,000 N. 327,500 N. 325,000 N. 322,500

200 Ft. HIGHWALL

COAL OUTCROP

SOIL MAPPING LEGEND

Depth of Surface Soil in Inches — Thickness of Subsoil in Inches — Thickness of Substratum in Inches Suitable for Use in Revegetation — SLOPES

Unconforming Substratum Not Considered Suitable for Use on the Land Surface for Revegetative Purposes. Includes:
- O Gravel or Stone
- S Shale
- R Sandstone

Example: 12 - 10 - 26 S / 2 F 2 6 / B

USEABLE SOIL DEPTHS
1. Very deep over 60
2. Deep 36 - 60
3. Moderately deep, 20 - 36
4. Shallow, 10 - 20
5. Very shallow, less than 10

SURFACE SOIL TEXTURE
- V Very heavy: 60 % or more clay
- H Heavy: Clay, silty clay, sandy clay, h. clay loam
- F Moderately heavy: Silty clay loam, silt
- M Medium: Silty loam, loam very fine sandy loam
- S Moderately light: Fine sandy loam, sandy loam, heavy loamy sand.
- L Light: loamy very fine sand, loamy fine sand, loamy sand.
- C or O Coarse: Sandy coarse sand, gravelly sand

SUBSOIL AND SUBSTRATUM PERMEABILITY
1. Very slow
2. Slow
3. Moderately slow
4. Moderate
5. Moderately rapid
6. Rapid
7. Very rapid

SLOPES
- A 0 - 5
- B 5 - 15
- C 15 - 25
- D 25 - 40
- E > 40

EXPLANATION
(2) Restoration Areas

NOTE
Coordinate base is taken from Utah International Inc. grid system

1000 0 1000 2000 3000
SCALE OF FEET

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
EMRIA PROJECT
UTAH

ALTON COAL FIELD
RESTORATION AREAS

COMPILED _____ SUBMITTED _____
DRAFTED _____ RECOMMENDED _____
CHECKED _____ APPROVED _____
BOULDER CITY, NEVADA MAY 8, 1975

1224-0A-300-45

(2) The 40 percent slopes of subarea 4a should be reduced and averaged into the remaining area.

(3) Area would be of priority for sprinkler irrigation.

5. Area 5

a. Description

This is one of the areas of best potential for revegetation.

b. Special Treatment

The deep usable soil depth provides a potential source of soil for use in other areas of shallow unsuitable soil.

6. Area 6

a. Description

The area has adequate top and subsoil depths with slopes less than 25 percent. Permeability is adequate and erosion hazard moderate.

b. Special Treatment

No special treatment required.

7. Area 7

a. Description

The area has adequate top and subsoil and slopes are less than 15 percent. Much of the soil is of a heavy texture with very slow permeability.

b. Special Treatment

Mulching is of special importance.

8. Areas 8, 9, 11, and 12

a. Description

These areas generally have usable soil material of adequate depth. The topography consists of steep slopes, 25 to 40 percent, rising from relatively flat broad drainageways to flat terrace tops. The erosion hazard on the steep slopes is critical to severe.

b. Special Treatment

There is some opportunity for reducing the steep slopes at the expense of reducing the flat terrace area. The steep slopes should be protected with mulch worked into the surface soil. The slopes have a short reach and terracing would be advisable.

9. Areas 10 and 13

a. Description

These areas receive water from a relatively large drainage and are major tributaries to Skutumpah Creek,

b. Special Treatment

Erosion retarding structures. Grade, seed channel.

10. Area 14

a. Decription

This area has gentle slopes and deep soils.

b. Special Treatment

No special treatment required. The deep usable soils offer potential as surface material for adjoining shallow soil areas.

11. Area 15

a. Description

The usable surface material over much of the area consists of about 14 inches of coarse material. The water-holding capacity of this material is low which would be detrimental to the reestablishment of vegetation.

b. Special Treatment

It would be beneficial to supply a minimum of six inches of medium-textured surface material from Area 14.

12. Areas 16 and 17

a. Description

These areas have slopes exceeding 40 percent rising from the Skutumpah Valley floor to the mesa areas. As the area is directly tributary to Skutumpah Creek, extra precaution is needed for protection from sediment escaping the mined area.

b. Special Treatment

The steep slope should be graded back to a maximum slope of 3:1. Dozer basins should be used to prevent erosion in combination with a heavy application of mulch worked into the soil.

IX. SUMMARY OF FINDINGS

IX. SUMMARY OF FINDINGS

1. Soil material on 42 percent of the study area is well suited for supporting revegetation efforts based on depth of material, water-holding capacity, texture and structure, cation exchange capacity, freedom from toxic concentrations of soluble salts, and favorable concentrations of gravel, cobble, or stone. Seventeen percent of the area is unsuited as a source of surface soil material. The remaining 41 percent of the area is marginal of varying suitability.

2. Revegetation will be more successful if surface soils are stockpiled and then replaced to a minimum depth of 18 inches on the reshaped overburden. Transporting of good soil material from areas of surplus to areas of shortage should be incorporated into the reclamation plan.

3. Erosion is an obvious problem and soils should be protected by surface treatments. Slopes exceeding 3:1 should be avoided.

4. Without irrigation the extreme variability of precipitation will reduce the success of revegetation. Limited success to complete failure can be expected on the average of two of every three years.

5. The soil surface should be contour furrowed or gouged. Mulch should be applied at the time of seeding. Existing trees can be shredded to provide the mulch desired.

6. A variety of herbaceous and woody species should be included in the revegetation for use by both domestic animals and livestock.

7. Arid land plant species may be required for revegetation because other species may require more frequent recharge than prevailing climate patterns provide.

8. Saline problems may develop in some areas from salts brought to the surface from the deep substrata. Soluble salts in the surface soils are not generally in concentrations sufficient to be considered a problem.

9. The present nearly pure stand of pinion and juniper provides very little forage for wildlife or livestock. Though the pinion and juniper can be expected to reoccupy the area in time, it should be possible to greatly improve the habitat for large herbivores.

10. About 99 percent of the coal resources in the study site are in the thick category, over 10 feet in thickness.

11. The original coal resources with 200 feet or less overburden in the Smirl Zone in the Alton EMRIA site and adjoining area total 93,334,000 short tons of which 27,247,000 tons are within the EMRIA site proper.

12. A comprehensive baseline inventory should be prepared as part of the rehabilitation plan and provisions made to monitor the onsite and offsite effects of mining and rehabilitation. The inventory should include land classification; geological classification of overburden material; surface and ground-water quantity and quality; topography; surface drainage, existing ecology, archeological, historical, and cultural values; and weather information. Monitoring of surface and ground-water quantity and quality, weather information, and ecology changes should continue for several years after rehabilitation is completed.

13. Sediment yield would be reduced if broad drainage valleys are designed into the reconstructed landscape.

14. The objectives of the rehabilitation plan including the ultimate land use should be clearly defined. Desires of the public should be determined through a public participation process sponsored by the responsible Federal agency.

15. Minimum protection and restoration standards and requirements should be clearly defined by the responsible Federal agency. This should include protection of major drainage courses from damage, protection of downstream surface or ground-water quality from deteriorating, requirements for the burying of toxic materials, if encountered, the reestablishment of positive drainage patterns, standards on final surface configuration, air pollution restrictions, minimum top and subsoil requirements, a timetable for restoration activities concurrent with the mining operations, and monitoring and management provisions. The best known methods of revegetating the disturbed areas should be used for obtaining the highest probabilities of success on all ecosystems.

16. A detailed reclamation plan tailored to the specific soil and slope conditions should be prepared prior to mining operations.

17. Alluvial valley floors and stream channels, such as Thompson and Skutumpah Creeks should be preserved.

18. Water from disturbed side drainages should be intercepted above the area being mined and transported below to undisturbed drainage courses or stored for onsite uses, such as irrigation and dust control.

19. Spoil piles should be on the contour to avoid excessive sediment reaching the major drainages from runoff.

20. Surface grading and contouring can best be accomplished on the backfill material prior to spreading the plant growth media.

21. Application of phosphate and nitrogen fertilizers would assist vegetation establishment. A balance must be maintained between available moisture and the nitrogen fertilizer applied.

22. Seeding should be accomplished by drilling where the terrain allows.

23. Sprinkler irrigation would greatly increase the early success of revegetation. It should be terminated 15 to 18 months after seeding.

24. Test plots should be established at an early stage of the mining operations to evaluate the effectivenss of the various rehabilitation practices. The test plots should be representative of the various types of problems to be encountered in the area.

25. Protection from grazing is a necessity for at least three growing seasons and on the harsher sites four or more growing seasons may be necessary.

26. Weeds on the revegetated site should be controlled at least during the first year.

27. Rehabilitation management plans should be included as part of the restoration and management provisions enforced until vegetative stability is assured.

28. Offsite social and economic impacts should be evaluated by the responsible Federal agency.

X. REFERENCES

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APPENDED MATERIAL

Table 3
UNITED STATES BUREAU OF RECLAMATION
Region 3
SOIL AND WATER LABORATORY
Soil Analysis

Lab. No.	Pit No.	in. Depth	Mechanical Analysis					PH 8.3 Me/100g	Sodium Meq./100 grams			ESP	SAR	Ml Settling Vol.	Exch. K Meq./100 g	pH		Saturation Extract Data									
			% >2mm	2.0 - .047 mm % Sand	.047 - .002 mm % Silt	<.002 mm % Clay	Class	CEC	PH 7.0 Ext. Na	Sol. Na	Exch. Na					Paste	1:5	Sat. %	EC_e x 10^3	Meq./L Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	NO_3
10.4	2	0-6	60	58.4	28.7	12.9	SL	21.60	.07	0.01	0.06	0.3	0.2	22	0.34	7.8	8.3	48.0	0.53	0.29	0.19	5.83	0.90	0	3.00	1.50	5.23	0.05
11.4		-17	80	58.5	26.2	15.3	SL	18.40	.12	0.03	0.09	0.5	0.3	23	0.17	7.8	8.3	48.1	0.57	0.62	0.21	5.22	1.48	0	4.00	1.50	2.03	0.14
12.4		-38	10	49.6	38.2	12.2	SL	11.40	.08	0.02	0.06	0.5	0.3	19	0.12	8.2	8.7	36.0	0.41	0.43	0.16	3.91	1.22	0	3.00	1.50	1.22	0.10
13.4		-68	0	52.1	31.2	16.7	SL-L	10.80	.11	0.02	0.09	0.8	0.3	19	0.12	8.3	8.9	35.1	0.37	0.47	0.10	2.42	2.19	0	2.20	1.50	1.48	<.01
14.4		-110	60	61.4	38.2	10.4	L-SL	6.50	.05	0.03	0.02	0.3	0.5	17	0.08	8.4	9.1	31.0	0.59	1.00	0.11	2.70	4.00	0	3.00	2.00	2.80	<.01
15.4		-130	0	46.2	44.4	9.4	L	6.90	.16	0.90	0.07	1.0	1.7	18	0.10	8.4	9.1	33.3	0.69	2.74	0.09	1.63	4.37	0	3.25	2.00	3.60	<.01
16.4	3	0-5	0	61.7	27.3	11.0	SL	16.40	.07	0.02	0.05	0.3	0.2	17	0.60	7.1	7.9	42.3	0.60	0.40	0.45	6.60	1.74	0	2.50	1.00	5.19	0.50
17.4		-10	2	57.5	29.5	13.0	SL	13.46	.04	0.02	0.02	0.1	0.5	17	0.57	7.1	7.8	31.8	0.51	0.71	0.45	3.60	1.20	0	1.25	1.50	3.21	0.12
18.4		-17	0	45.5	32.3	22.2	L	19.10	.04	0.02	0.02	0.3	0.4	20	0.64	6.5	7.3	36.3	0.28	0.49	0.45	2.33	0.79	0	1.25	3.00	0.10	<.01
19.4		-34	0	45.8	31.2	23.0	L	18.20	.06	0.02	0.04	0.2	0.4	20	0.55	6.4	7.2	33.1	0.37	0.52	0.08	2.50	0.85	0	1.25	2.00	0.70	<.01
20.4		-50	2	50.6	23.0	26.4	SCL	20.00	.07	0.02	0.05	0.3	0.5	21	0.35	6.8	7.5	38.1	0.38	0.59	0.12	2.48	0.82	0	1.50	2.00	0.51	<.01

Form
Region 3
March 1970

UNITED STATES BUREAU OF RECLAMATION
Region 3
SOIL AND WATER LABORATORY
Soil Analysis

Lab. No.	Pit No.	in. Depth	Mechanical Analysis					PH 8.3	Sodium Meq./100 grams			ESP	SAR	MI Set-tling Vol.	Exch. K Meq./100 g	pH		Saturation Extract Data									
			2.0 - .047 mm % >2mm	.047 - .002 mm % Sand	<.002 mm % Silt	% Clay	Class	Me/100g CEC	PH 7.0 Ext. Na	Sol. Na	Exch. Na					Paste	1:5	Sat. %	EC_e x 10^3	Meq./L Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	NO_3
25.4	5	0-8	0	61.5	26.3	12.2	SL	10.00	0.10	0.02	0.08	0.8	0.4	18	0.36	6.3	7.1	32.8	0.28	0.61	0.18	2.53	1.32	0	0.75	3.00	0.89	0.10
26.4		-25	0	24.5	32.4	43.1	C	29.30	0.16	0.07	0.09	0.3	1.1	27	0.53	6.5	7.4	50.0	0.35	1.32	0.07	1.58	1.23	0	1.25	2.00	0.95	0.07
27.4		-56	0	27.5	48.8	23.7	L-SiL	16.56	0.23	0.07	0.16	1.0	1.1	27	0.24	7.9	8.7	48.3	0.53	1.45	0.09	2.38	1.44	0	3.25	2.00	0.11	<.01
28.4	6	0-14	0	75.4	19.0	5.6	SL-LS	6.38	0.07	0.01	0.06	0.9	0.3	14	0.22	6.9	7.6	34.0	0.30	0.37	0.15	2.43	0.86	0	1.50	2.00	0.31	<.01
29.4		-16	0	55.8	20.4	23.8	SCL	15.40	0.08	0.01	0.07	0.5	0.3	20	0.36	6.1	6.8	37.0	0.25	0.38	0.06	2.49	0.94	0	0.50	2.00	1.32	<.01
30.4		-30	0	54.6	15.8	29.6	SCL	17.62	0.06	0.03	0.03	0.2	0.5	21	0.36	6.1	6.9	49.0	0.28	0.54	0.04	1.94	0.60	0	0.75	2.00	0.37	<.01
31.4		-114	0	3.7	42.1	54.2	SiC	41.88	1.86	0.63	1.23	2.9	4.9	50	0.56	8.1	8.9	85.5	1.16	7.34	0.16	2.07	2.34	0	2.25	4.00	5.66	<.01
32.4	7	0-6	0	0.9	42.4	56.7	SiC	41.00	0.16	0.09	0.07	0.2	0.6	38	0.97	7.5	8.1	76.9	0.60	1.17	0.21	5.81	1.10	0	2.00	2.00	4.29	<.01
33.4		-14	0	0.7	44.8	54.5	SiC	37.00	1.08	0.58	0.50	1.4	1.9	33	0.73	7.5	7.7	78.5	2.85	7.48	0.58	28.60	4.00	0	1.25	1.50	37.90	<.01
34.4		-22	0	1.1	56.6	42.3	SiC	35.24	4.72	0.59	4.11	11.7	1.9	34	0.76	7.7	7.8	74.0	4.90	7.95	0.60	32.10	4.02	0	1.25	3.00	40.40	<.01
35.4		-38	0	2.1	55.6	42.3	SiC	34.20	9.48	4.42	5.06	14.8	12.0	36	0.63	7.9	7.9	79.0	7.90	55.90	0.68	23.40	20.10	0	1.25	6.00	92.80	<.01
36.4		-120	0	4.4	52.6	43.0	SiC	34.20	11.65	6.15	5.50	16.1	15.8	38	0.95	7.9	8.0	80.2	9.00	76.70	0.97	26.20	17.80	0	1.00	14.50	106.0	<.01

Form
Region 3
March 1970

UNITED STATES BUREAU OF RECLAMATION
Region 3
SOIL AND WATER LABORATORY
Soil Analysis

Lab. No.	Pit No.	Depth	Mechanical Analysis					PH 8.3	Sodium Meq./100 grams			ESP	SAR	Ml Settling Vol.	Exch. K Meq./100 g	pH		Saturation Extract Data									
																				Meq./L							
			% >2mm	2.0-.047 mm % Sand	.047-.002 mm % Silt	<.002 mm % Clay	Class	Me/100g CEC	PH 7.0 Ext. Na	Sol. Na	Exch. Na					Paste	1:5	Sat. %	$EC_e \times 10^3$	Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	NO_3
37.4	8	0-14	0	57.7	28.3	14.0	SL	8.44	0.32	0.05	0.27	3.2	0.6	16	0.32	6.3	7.4	47.4	0.74	1.10	0.16	5.69	2.24	0	1.75	2.00	5.44	.01
38.4		-33	0	67.1	7.6	25.3	SCL	15.10	0.08	0.04	0.04	0.3	0.6	20	0.33	6.3	7.3	40.2	0.46	0.99	0.11	3.48	2.32	0	1.75	2.00	3.15	.01
39.4		-46	0	65.7	17.5	16.8	SL	9.78	0.08	0.02	0.06	0.6	0.4	19	0.20	6.9	7.5	35.2	0.49	0.68	0.09	4.52	2.59	0	2.75	1.50	3.63	.01
40.4		-59	0	69.1	15.9	15.0	SL	9.10	0.11	0.08	0.03	0.3	0.8	20	0.15	7.2	7.6	39.0	1.30	2.02	0.12	5.28	7.69	0	1.50	2.75	10.86	.01
41.4		62-106	0	68.2	20.2	11.6	SL	5.64	0.28	0.25	0.03	0.5	1.1	18	0.11	7.8	8.3	39.0	5.30	6.48	0.34	26.30	45.30	0	2.00	8.00	68.42	.01
45.4	10	0-9	0	4.8	52.0	43.2	SiC	36.40	0.10	0.03	0.07	0.2	0.5	26	1.64	7.5	7.7	65.7	0.25	0.45	0.68	1.08	0.30	0	0.75	1.25	0.25	.18
46.4		-25	0	5.5	46.0	48.5	SiC	33.12	0.20	0.04	0.16	0.5	0.4	33	1.00	7.6	8.0	67.0	0.47	0.65	0.34	4.26	1.80	0	2.50	1.50	3.05	.20
47.4		-55		5.2	46.3	48.5	SiC	37.00	0.53	0.02	0.51	1.4	1.6	37	1.00	7.8	8.1	63.0	0.80	2.61	0.42	4.03	1.53	0	2.50	3.00	3.09	.22
48.4		-103		10.6	41.1	48.3	SiC	32.44	2.53	1.57	0.96	3.0	5.3	30	0.93	7.6	7.9	64.0	5.50	24.50	1.20	27.10	16.00	0	1.25	17.50	50.00	.42

Form
Region 3
March 1970

UNITED STATES BUREAU OF RECLAMATION
Region 3
SOIL AND WATER LABORATORY
Soil Analysis

Lab. No.	Pit No.	In. Depth	Mechanical Analysis					PH 8.3 Me/100g	Sodium Meq./100 grams			ESP	SAR	Ml Set-tling Vol.	Exch. K Meq./ 100 g	pH		Saturation Extract Data									
			% >2mm	2.0 - .047 mm % Sand	.047 - .002 mm % Silt	< .002 mm % Clay	Class	CEC	PH 7.0 Ext. Na	Sol. Na	Exch. Na					Paste	1:5	Sat. %	$EC_e \times 10^3$	Meq./L Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	NO_3
49.4	11	0-6	0	28.3	53.7	18.0	SiL	30.80	0.10	0.02	0.08	0.3	0.1	22	1.70	7.5	7.6	53.9	1.28	0.27	0.84	17.35	2.75	0	2.50	1.50	15.70	2.98
50.4		-13	3.9	22.1	49.7	28.2	CL-HL	30.38	0.12	0.02	0.10	0.3	0.2	23	0.97	7.6	7.9	53.0	0.52	0.41	0.32	5.30	0.85	0	1.25	3.00	2.40	0.46
51.4		-35	3.4	25.3	38.4	36.3	CL	32.00	0.10	0.03	0.07	0.2	0.3	25	0.58	7.8	8.1	57.0	0.50	0.55	0.09	5.52	1.35	0	2.50	2.00	2.90	0.28
52.4		-74	0	35.2	28.5	35.3	CL	26.00	0.13	0.04	0.09	0.3	0.5	23	0.50	7.8	8.2	47.1	0.52	0.76	0.11	3.72	1.38	0	2.25	1.50	2.20	0.22
53.4		-88	2.5	36.9	35.7	27.4	L-CL	20.50	0.07	0.04	0.03	0.1	0.5	21	0.40	7.8	8.4	48.3	0.50	0.80	0.11	3.80	2.04	0	2.75	2.50	1.50	0.20
54.4		-136	80	66.2	15.8	18.0	SL	14.30	0.16	0.10	0.06	0.4	1.2	18	0.32	8.0	8.6	41.3	1.00	2.49	0.16	3.55	4.66	0	2.25	6.00	2.60	0.18
58.4	13	0-9	0	56.9	33.5	9.6	SL	9.78	0.05	0.01	0.04	0.4	0.2	16	0.54	7.0	7.0	35.0	0.50	0.39	0.56	3.92	1.28	0	1.75	2.00	2.40	0.08
59.4		-19	0	48.6	32.4	19.0	L-SL	13.20	0.04	0.02	0.02	0.1	0.3	18	0.54	6.7	6.9	31.1	0.53	0.50	0.37	4.53	1.08	0	2.25	1.50	2.73	0.02
60.4		-34	15	1.7	59.3	39.0	SiCL	20.00	0.06	0.04	0.02	0.2	0.5	21	0.44	6.8	7.0	50.5	0.46	0.73	0.10	3.30	1.05	0	2.00	2.00	1.18	0.02

Form
Region 3
March 1970

UNITED STATES BUREAU OF RECLAMATION
Region 3
SOIL AND WATER LABORATORY
Soil Analysis

Strip Mine Area - Kanab, Utah

2-28-74

Lab. No.	Site No.	in. Depth	Mechanical Analysis % >2mm	2.0-.047 mm % Sand	.047-.002 mm % Silt	<.002 mm % Clay	Class	PH 8.3 Me/100g CEC	Sodium Meq./100 grams PH 7.0 Ext. Na	Sol. Na	Exch. Na	ESP	SAR	MI Set-tling Vol.	Exch. K Meq./ 100 g	pH Paste	pH 1:5	Saturation Extract Data Sat. %	EC_e x 10^3	Meq./L Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	NO_3
S 1.5	DH 105	65.0-76.4	<1.0	3.6	46.9	49.5	SiC	49.55	1.90	0.94	0.96	1.9	2.5	36	0.69	7.5	7.9	88.0	3.75	11.64	.64	28.59	13.98	0	1.20	2.78	53.60	0.15
S 2.5	DH 105	76.4-90.8	<1.0	8.5	55.0	36.5	SiCL	38.20	4.65	1.51	3.14	8.2	15.6	36	0.76	7.8	8.6	64.0	2.90	24.20	.64	1.66	3.10	0	2.20	2.00	28.00	0.22
S 3.5	DH 105	90.8-109.8	<1.0	5.8	61.5	32.7	SiCL	55.95	15.90	1.68	14.22	25.4	41.6	140	1.13	8.5	9.5	91.8	1.95	18.13	.25	0.30	0.46	0	3.00	1.27	15.00	0.70
S 4.5	DH 105	109.8-116.9	<1.0	7.2	48.6	44.2	SiC	73.05	30.65	1.30	29.27	40.1	57.6	320	1.33	9.3	9.9	152.	0.93	9.10	.10	0.15	0.25	0	3.10	0.60	5.80	0.48
S 5.5	DH 105	116.9-122.7	<1.0	1.8	63.4	34.8	SiCL	41.70	18.25	1.97	16.28	39.0	83.9	90	1.13	8.8	9.6	88.7	2.20	22.20	.24	0.07	0.07	0	5.40	0.60	15.75	0.54
S 6.5	DH 105	122.7-127.7	<1.0	4.3	54.9	40.8	SiC	36.70	16.50	1.93	14.57	39.7	80.5	90	1.13	8.6	9.7	90.7	2.05	21.30	.24	0.07	0.07	0	5.40	0.60	14.25	0.49
S 7.5	DH 105	127.7-131.6	<1.0	10.8	54.0	35.2	SiCL	31.45	13.55	2.66	10.89	34.6	76.4	90	0.87	8.5	9.6	82.2	3.20	32.40	.36	0.15	0.21	0	4.20	0.30	28.00	0.49
S 8.5	DH 105	131.6-136.4	<1.0	10.9	51.6	37.5	SiCL	37.95	17.55	2.04	15.51	40.9	80.0	150	1.08	8.7	9.7	93.0	2.10	21.90	.21	0.07	0.08	0	5.70	0.60	15.00	0.48
S 9.5	DH 105	136.4-141.1	<1.0	10.3	48.8	40.9	SiC	53.70	26.30	2.32	23.98	44.7	80.9	170	1.13	8.9	9.7	135.	1.75	17.16	.15	0.04	0.05	0	4.80	0.60	11.50	0.26
S10.5	DH 105	141.1-147.8	<1.0	8.1	45.4	46.5	SiC	63.95	32.55	2.65	29.90	46.8	81.8	240	1.47	9.1	9.7	145.	1.75	18.30	.15	0.04	0.06	0	4.80	0.60	12.50	0.28
S11.5	DH 105	147.8-153.0	<1.0	5.6	38.9	55.5	C	74.00	35.95	2.15	33.80	45.7	85.5	500	1.53	9.4	9.9	205.	1.05	10.47	.10	0.01	0.02	0	5.10	0.10	5.00	0.30
S12.5	DH 105	153.0-160.7	<1.0	16.2	38.1	45.7	C	51.50	24.65	1.98	22.67	44.0	87.2	250	1.23	9.1	9.7	131.	1.50	15.10	.12	0.02	0.04	0	5.10	0.20	9.50	0.30
S13.5	DH 105	160.7-164.5	<1.0	29.5	56.2	14.3	SiL	14.80	4.12	2.52	1.60	10.8	14.1	25	0.21	7.0	7.5	41.0	7.60	61.35	1.15	26.55	11.10	0	5.76	1.44	91.80	0.46
S14.5	DH 105	164.5-169.0	<1.0	64.9	27.1	8.0	SL	7.06	1.60	1.24	0.36	5.1	9.6	17	0.13	7.2	7.8	31.6	5.60	39.33	.96	25.24	8.39	0	3.30	1.20	68.50	0.51
S15.5	DH 105	188.5-191.0	<1.0	9.2	53.6	37.2	SiCL	16.25	5.90	2.97	2.93	18.0	61.0	280	0.53	8.9	9.8	104.	3.20	28.60	.22	0.08	0.36	0	14.60	7.05	8.00	0.18

Form
Region 3
March 1970

UNITED STATES BUREAU OF RECLAMATION
Region 3
SOIL AND WATER LABORATORY
Soil Analysis

Strip Mine Area - Kanab, Utah

2-28-74

Lab. No.	Site No.	in. Depth	Mechanical Analysis					PH 8.3	Sodium Meq./100 grams					MI Set-tling	Exch. K	pH		Saturation Extract Data										
			% >2mm	2.0 .047 mm % Sand	.047 .002 mm % Silt	<.002 % Clay	Class	Me/100g CEC	PH 7.0 Ext. Na	Sol. Na	Exch. Na	ESP	SAR	Vol.	Meq./ 100 g	Paste	1:5	Sat. %	EC_e x 10^3	Meq./L Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	NO_3
S16.5	DH 105	191.0-196.7'	<1.0	17.0	43.1	39.9	SiCL	16.00	8.20	3.11	5.09	31.8	59.2	300.	0.72	8.7	9.6	106.	3.20	29.30	0.32	0.05	0.44	0	17.60	5.76	8.00	0.22
S17.5	DH 105	196.7-205.5'	<1.0	18.9	40.6	40.5	SiC	17.15	7.15	2.66	4.49	26.2	47.1	300.	0.58	9.0	9.5	111.	2.70	24.00	0.18	0.34	0.49	0	14.00	5.66	6.25	0.20

Form
Region 3
March 1970

Table 4
Laboratory Data
Kanab Strip Mine Area

Backhoe Pit Profiles

Field dentity	Depth Inches	Bulk Density	Est. Lime	pH_2 in .01M $CaCl_2$	2/ Gypsum	Boron ppm	3/ P ppm	1/ Est. S	Dist. 2 hr	Perm. 6 hr	in/hr 24 hr	15 Bar. Moist. %
Pit #2	0-6		2	7.3	0	0.76	16.0	0	0.46	0.54	0.46	11.6
	6-17		2	7.3	0	1.80	6.5	0	0.63	0.75	0.71	12.3
	17-38		3	7.5	0	0.65	2.6	0	0.15	0.17	0.17	7.8
	38-68		3	7.7	0	1.30	<1.0	0	0.20	0.20	0.22	8.0
	68-110		3	7.8	0	0.70	<1.0	0	0.20	0.20	0.24	6.1
	110-130		3	7.9	0	1.60	1.3	I	0.20	0.22	0.24	5.8
Pit #3	0-5		0	7.5	0	1.20	24.0	0	0.74	0.85	0.82	7.8
	5-10	1.50	0	6.8	0	1.70	21.0	0	0.33	0.37	0.37	6.9
	10-17	1.66	0	6.4	0	0.35	18.0	0	0.13	0.15	0.15	9.8
	17-34	1.88	0	6.3	0	1.30	15.0	0	0.13	0.11	0.13	9.7
	34-50	1.85	0	6.5	0	1.30	13.0	0	0.24	0.28	0.28	11.3
Pit #5	0-8		0	6.0	0	0.65	3.9	0	0.24	0.31	0.24	5.7
	8-25		0	6.3	0	1.40	<1.0	0	0.02	0.06	0.06	17.4
	25-56		2	7.6	0	1.40	<1.0	0	0.02	0.06	0.04	12.0
Pit #6	0-4		0	6.7	0	0.35	5.2	0	0.63	0.71	0.75	3.5
	4-16		0	5.7	0	0.35	<1.0	0	0.37	0.37	0.55	9.7
	16-30		0	5.8	0	1.30	<1.0	0	0.39	0.42	0.50	12.4
	90-114		3	7.0	0	1.30	<1.0	0	*2/3	*9/10	.01	23.9
Pit #7	0-6	1.79	2	6.3	0	0.65	<1.0	0	*	0.02	0.02	22.3
	6-14	1.86	2	7.3	M-H	1.30	<1.0	0	*9/10	0.02	0.02	23.0
	14-22	1.92	2	7.5	H	1.30	<1.0	0	*2/3	*	.01	23.2
	22-38	1.78	2	7.8	H	1.50	<1.0	0	*5/8	*	.01	23.8
	38-120	2.00	3	7.8	H	0.70	<1.0	0	*5/8	*3/4	*	23.2
Pit #8	0-14	1.46	0	6.4	0	0.45	13.0	0	0.63	0.63	0.56	5.5
	14-33	1.79	0	6.4	0	1.10	7.8	0	0.26	0.26	0.28	9.9
	33-46	1.79	0	6.7	0	0.95	5.9	0	0.43	0.43	0.47	5.6
	46-59	1.77	0	7.2	0	0.95	5.9	0	0.35	0.33	0.35	5.2
	62-106	1.77	1	7.9	VL	0.95	5.0	0	0.94	0.94	0.98	4.0
Pit #10	0-9	1.45	3	7.4	0	1.00	10.0	I	0.02	0.06	0.04	17.1
	9-25	1.73	3	7.6	0	1.40	<1.0	I	*	0.04	0.04	18.8
	25-55	1.76	3	7.7	0	0.95	<1.0	I	*7/8	0.02	0.04	18.5
	55-103	1.86	3	7.7	M	0.80	<1.0	I	*9/10	0.04	0.04	17.9
Pit #11	0-7		1	7.4	0	0.80	23.0	0	0.22	0.20	0.18	13.4
	7-13		2	7.6	0	0.80	2.6	I	0.18	0.18	0.16	14.2
	13-35		3	7.7	0	0.65	<1.0	I	0.07	0.07	0.09	15.0
	35-74		4	7.7	0	0.80	<1.0	I	0.08	0.08	0.08	13.0
	74-88		3	7.7	0	0.60	<1.0	I	0.22	0.20	0.22	9.8
	88-136		3	7.8	0	0.76	<1.0	I	0.28	0.30	0.33	7.6
Pit #13	0-9	1.81	0	6.3	0	0.70	20.0	0	0.41	0.43	0.37	4.5
	9-19	1.81	0	6.4	0	0.50	12.0	0	0.28	0.30	0.33	6.8
	19-34	1.85	0	6.4	0	0.50	1.3	0	0.20	0.22	0.26	12.4

/ Method - Field Test for Active Sulfides in Soil, J. W. Neckers and Charles R. Walters, 1952-74: 467-470.

/ A portion of the 1:5 soil water was decanted into a test tube. Acetone was added and the precipitate, if any, was observed. VL = very light, L = light, M = moderate, and H = heavy.

/ $NaHCO_3$ extractable.

Asterisk indicates that the soil column was completely wetted during the time frame shown, but that no water passed through the soil column during that time frame. The asterisk with a fraction (*1/10) indicates that only the top 1/10 of the 9 centimeters soil column was wetted during the time frame indicated.

Table 5a
Laboratory Data
Kanab Strip Mine Area

Drill Hole Profiles

Field Identity	Depth Feet	Lab No.	Est. Lime	pH₂ in .01M $CaCl_2$	2/ Gypsum	Boron ppm	1/ Est. S	Gypsum Req. meq/100 g	15 Bar. Moist. %
DH-105	65.0- 76.4	1.5	3	7.6	0	0.80	I	0	22.8
	76.4- 90.8	2.5	3	7.7	0	1.00	I	0	15.7
	90.8-109.8	3.5	2	8.4	0	1.10	I	8.24	22.0
	109.8-116.9	4.5	2	9.0	0	0.50	I	18.70	37.8
	116.9-122.7	5.5	1	8.6	0	1.20	II	10.70	18.2
	122.7-127.7	6.5	2	8.5	0	1.20	I	8.66	18.3
	127.7-131.6	7.5	3	8.5	0	1.40	II	4.90	14.7
	131.6-136.4	8.5	3	8.6	0	1.40	II	12.50	20.1
	136.4-141.1	9.5	2	8.8	0	1.50	II	17.10	31.3
	141.1-147.8	10.5	2	8.9	0	1.10	II	18.70	24.5
	147.8-153.0	11.5	1	9.1	0	0.85	II	23.50	29.7 3/
	153.0-160.7	12.5	1	8.9	0	1.10	III	17.90	24.7
	160.7-164.5	13.5	1	6.8	0	4.00	III	0	7.2
	164.5-169.0	14.5	3	7.1	0	3.40	II	0	3.6
	188.5-191.0	15.5	2	8.2	0	1.70	II	1.70	14.1
	191.0-196.7	16.5	2	8.2	0	1.80	III	3.82	17.3
	196.7-205.5	17.5	1	8.6	0	1.50	III	3.30	16.3

1/ Method - Field Test for Active Sulfides in Soil, J. W. Neckers and Charles R. Walters, 1952-74: 467-470.

2/ A portion of the 1:5 soil water was decanted into a test tube. Acetone was added and the precipitate, if any, was observed. VL = very light, L = light, M = moderate, and H = heavy.

3/ Not completely wet after sitting in water for 48 hours.

Table 5
Laboratory Data
Kanab Strip Mine Area

Drill Hole Profiles

Field Identity	Depth Feet	Est. Lime	pH in .01M $CaCl_2$	pH 1:5	ECx10^3 1:5	Settling Volume	1/ Est. S	Gypsum Req. meq/100 g	Dist. 2 hr	Perm. 6 hr	in/hr 24 hr	15 Bar. Moist. %
DH-101	91.8- 92.3	1	7.9	8.7	0.58	37	I	3.02				15.6
	136.4-136.9	2	8.5	9.3	0.50	100	I	11.90				17.6
	161.4-161.9	2	8.6	9.5	0.78	90	I	11.50				17.7
	196.9-197.4	2	7.1	7.8	0.72	21	III	0				3.5
DH-103	56.8- 57.3	2	8.2	9.1	0.52	70	I	4.22				17.1
	61.6- 68.9	2	8.4	9.4	0.56	80	II	8.67	*1/6	*1/4	*1/3	17.2
	90.1- 90.6	2	9.1	9.3	0.68	120	II	13.90				23.5
	100.4-100.9	2	8.7	9.4	0.73	140	I	17.90				27.7
	108.5-109.0	2	8.7	9.4	0.60	80	II	10.70				18.0
	115.6-116.1	2	8.7	9.4	0.70	120	III	12.70				20.5
	120.5-121.0	1	8.7	9.5	0.90	250	III	25.10				32.6 2/
	125.0-135.0	1	9.2	10.0	0.71	380	III	25.50	*1/10	*1/10	*1/8	38.4
	144.5-145.0	1	9.0	9.6	0.63	120	IV	9.45				18.1 2/
	177.2-185.3	1	8.7	9.7	0.70	170	III	14.3	*1/10	*1/10	*1/6	20.0
DH-104	39.3- 39.8	2	7.8	8.1	1.82	38	0	0				21.5
	67.8- 68.3	1	8.3	9.1	0.45	65	II	5.43				32.3
	68.3- 68.8	1	8.3	8.9	0.57	65	I	5.43				29.3
	70.6- 71.1	1	8.0	8.8	0.40	30	II	2.61				13.8
	79.4- 79.9	1	6.7	7.3	1.15	20	III	0				5.3

* Disturbed permeability measurements were conducted for three zones in DH-103. The asterisk with a fraction (*1/10) indicates that only the top 1/10 of the 9 centimeters soil column was wetted during the time frame shown.

1/ Method - Field Test for Active Sulfides in Soil, J. W. Neckers and Charles R. Walters, 1952-74: 467-470.

2/ Not completely wet after sitting in water for 48 hours.

Table 6

WEATHERING TESTS
Core Samples from Kanab, Utah

Laboratory sample No.	Sample I.D.	Rock classification	No. of pieces	Remarks		
				Cycles 1-10	Cycles 11-20	Cycles 21-30
K-1F	K(103)1-74	Shale	1	C 1 Cy; Sv C 2 Cy; Sat 9 Cy	Sk 12 Cy; Sv Sk 15 Cy; BD 16 Cy	% BD 100
1W	Depth 40.2' - 41.1		1	C 1 Cy; Sv C 6 Cy; F 9 Cy	Sv Sk 16 Cy; BD 19 Cy	% BD 100
K-2F	K(103)2-74	Shale	2	C 2 Cy; Sv C 4 Cy; S Sat 5 Cy	Sat 10 Cy; S Sk 16 Cy	Sk 26 Cy % BD 100
2W	Depth 70.3' - 71.2'		1	SC 1 Cy; C 6 Cy	Sv C 16 Cy; S Sk 18 Cy	Sv Sk 26 Cy % BD 100
K-4F	K(103)4-74	Shale	1	C 2 Cy; Sat 4 Cy; Sat 9 Cy	Cv 15 Cy	% BD 100
4W	Depth 131.6' - 132.5'		1	NC	S Sk 18 Cy	Sp 21 Cy; P Sk 26 cy; % BD 61.7
K-8F	K(103)8-74	Shale	1	S Sat 3 Cy; Sat 5 Cy; C 9 Cy	Sv C 18 Cy	Sw 20 Cy; % BD 53.6
8W	Depth 215.4' - 216.2'		1	NC	NC	S Sc 25 Cy; % BD 5

Table 6

WEATHERING TESTS
Core Samples from Kanab, Utah

Laboratory sample No.	Sample I.D.	Rock classification	No. of pieces	Remarks		
				Cycles 1-10	Cycles 11-20	Cycles 21-30
K-10F	K(105)2-74	Shale	1	C 1 Cy; Sv C 9 Cy	Cv 14 Cy	Sv Cv 22 Cy; % BD 100
10W	Depth 118.1' - 119.1'		1	C 1 Cy	Sv C 13 Cy	Sk 26 Cy; % BD 52.1
K-11F	K(105)3-74	Shale	1	C 1 Cy; Sv C 9 Cy; S Sat 5 Cy	Sat 14 Cy; Cv 18 Cy	% BD 100
11W	Depth 153.5' - 154.4'		1	SC 1 Cy; C 6 Cy	Sv C 11 Cy	Cv, Sk 23 Cy, % BD 69.3
K-12F	K(105)4-74	Shale	1	SC 1 Cy; C 3 Cy	S Sat 12 Cy; Sw 15 Cy	Cv 22 cy; % BD 100
12W	Depth 158.2' - 159.1'		1	SC 1 Cy; C 3 Cy	Sv C 11 Cy	Sk 26 Cy; % BD 23.4
K-15F	K(105)	Sandstone	1	NC	NC	v S Sc 25 Cy; % BD 0.5
15W	Depth 166.8' - 167.8'		1	NC	NC	S Sc 26 Cy % BD.0

Table 7

ABBREVIATIONS USED IN TABLES

Abbreviation	Meaning
BD	Breakdown
C	Cracking
Cv	Cleaving
Cy	Cycle
F	Freeze-thaw sample
Fr	Friable
NC	No change
ND	Not determined
P	Peeling
S	Slight (Slightly)
Sat	Saturated
Sc	Scouring
Sk	Slaking
Sp	Slumping
Sv	Severe
Sw	Swelling
v	Very
W	Wet-dry sample
%	Percent

Table 8
DRY GRADATION ANALYSIS

Sieve Size	Cumulative Percent Passing by Weight			
	K-1F	K-1W	K-10F	K-10W
4	100	93.8	97.3	61.6
10	99.8	21.2	96.5	20.8
50	17.3	1.8	25.0	3.3
100	6.7	0.9	7.7	2.2
200	2.8	0.5	3.6	2.1

Note: Samples dried for 48 hours at 100°F before gradation analysis.

TABLE 9 GREENHOUSE DATA FOR UTAH SITE

Sample No.	Depth (in.)	Pot wt. (Kg)	Germination: Days After Seeding for Ten Plants to Emerge I	Germination: Days After Seeding for Ten Plants to Emerge II	Germination: No. of Seeds Germinated I	Germination: No. of Seeds Germinated II	Salt Crust at Germination	Salt Crust at Harvest	Harvest: Plant Dry Weight (gm) I	Harvest: Plant Dry Weight (gm) II	Harvest: Avg. Plant Height (cm) I	Harvest: Avg. Plant Height (cm) II	Black Leaf Tips	Soil Surface Cracks	Field Cap. %
K(2)1-74	0-6	2	6	6	33	26	0	0	1.56	1.31	35	29	3	0	12.6
K(2)2-74	6-17	2	7	7	30	32	0	0	2.11	2.12	35	30	3	0	13.1
K(2)3-74	17-38	2	7	7	30	31	0	0	1.19	1.04	29	26	4	0	9.7
K(2)4-74	38-68	2	7	7	35	31	0	0	1.49	1.67	29	29	3	0	11.9
K(2)5-74	68-110	2	6	6	33	30	0	0	1.44	1.17	32	30	0	0	10.5
K(2)6-74	110-130	2	6	6	32	34	0	0	1.03	1.05	30	30	2	0	10.1
K(3)1-74	0-5	2	6	6	35	35	0	0	3.12	3.58	41	33	4	0	15.3
K(3)2-74	5-10	2	6	6	32	35	0	0	2.36	2.10	37	30	2	0	11.6
K(3)3-74	10-17	2	6	6	34	35	0	0	2.39	2.25	39	32	2	0	13.1
K(3)4-74	17-34	2	6	6	31	32	0	0	2.72	2.44	40	27	0	0	14.4
K(3)5-74	34-50	2	6	6	32	32	0	0	2.07	1.90	37	31	2	0	12.2
K(5)1-74	0-8	2	6	6	31	35	0	0	2.26	2.25	37	37	2	0	10.5
K(5)2-74	8-25	2	6	6	29	28	0	0	1.35	1.38	26	27	2	0	12.2
K(5)3-74	25-56	2	7	7	22	18	0	0	1.55	1.37	30	30	3	2	11.5
K(6)1-74	0-4	2	6	6	34	30	0	0	3.36	2.59	42	35	3	0	19.1
K(6)2-74	4-16	2	5	5	34	35	0	0	0.99	1.23	28	29	3	0	10.6
K(6)3-74	16-30	2	6	6	33	35	0	0	0.45	0.79	33	27	4	0	10.7
K(6)4-74	90-114	2	6	6	34	33	0	0	0.45	0.73	16	19	0	3	13.2
K(7)1-74	0-6	2	6	6	31	34	0	0	3.03	2.96	40	38	0	0	22.3
K(7)2-74	6-14	2	6	6	32	35	3	0	0.65	0.76	24	23	0	2	13.7
K(7)3-74	14-22	2	6	6	33	32	3	0	0.89	0.77	26	25	0	2	14.9
K(7)4-74	22-38	2	7	7	31	35	0	0	1.33	0.92	31	23	0	2	14.4
K(7)5-74	38-120	2	10	12	33	30	2	0	0.34	0.32	15	19	2	4	10.6
K(7)c-74	0-22	2	6	6	32	31	0	0	0.65	0.63	22	21	0	2	13.5

TABLE 9 Continued GREENHOUSE DATA FOR UTAH SITE

Sample No.	Depth (in.)	Pot wt. (Kg)	Germination: Days After Seeding for Ten Plants to Emerge I	II	Germination: No. of Seeds Germinated I	II	Salt Crust at Germination	Salt Crust at Harvest	Harvest: Plant Dry Weight (gm) I	II	Harvest: Avg. Plant Height (cm) I	II	Black Leaf Tips	Soil Surface Cracks	Field Cap. %
K(8)1-74	0-14	2	6	6	31	32	0	0	2.69	2.59	39	38	3	0	10.7
K(8)2-74	14-33	2	5	5	34	32	0	0	1.85	1.80	37	31	3	0	12.3
K(8)3-74	33-46	2	6	6	30	31	0	0	2.16	2.25	33	38	3	0	10.6
K(8)4-74	46-59	2	6	6	30	31	0	0	2.26	2.18	38	38	2	0	10.6
K(8)5-74	62-106	2	8	8	30	27	0	0	1.01	1.01	28	27	3	0	9.8
K(10)1-74	0-9	2	6	6	33	33	0	0	0.49	0.60	17	19	0	3	11.3
K(10)2-74	9-25	1.95	6	6	35	33	0	0	2.97	2.89	35	37	2	0	19.9
K(10)3-74	25-55	2	6	6	31	34	0	0	1.53	1.88	33	31	0	3	17.2
K(10)4-74	55-103	2	6	6	30	29	3	0	2.44	2.79	38	35	0	0	25.7
K(10)c-74	0-55	2	6	6	33	34	0	0	1.33	1.22	28	29	2	3	16.2
K(11)1-74	0-7	2	6	6	34	32	0	0	2.69	2.57	36	38	2	0	19.4
K(11)2-74	7-13	2	5	5	33	35	0	0	1.22	1.29	28	29	2	2	13.2
K(11)3-74	13-35	2	6	6	35	35	0	0	1.07	2.66	27	35	0	0	13.2
K(11)4-74	35-74	2	6	6	30	32	0	0	1.04	0.86	26	25	3	1	12.7
K(11)5-74	74-88	2	6	6	32	32	0	0	3.06	2.79	36	37	0	0	15.3
K(11)6-74	88-136	2	6	6	34	27	0	0	1.44	1.74	30	29	2	0	9.5
K(11)c-74	0-74	2	6	6	34	33	0	0	1.11	1.33	27	27	3	0	13.1
K(13)1-74	0-9	2	6	6	34	34	0	0	2.13	2.34	35	35	3	0	10.1
K(13)2-74	9-19	2	5	5	24	34	0	0	3.23	3.86	45	42	0	0	10.2
K(13)3-74	19-34	2	6	6	28	31	0	0	3.34	2.71	39	36	2	0	12.3
K(13)c-74	0-34	2	6	6	31	31	0	0	0.86	1.01	25	26	4	0	9.4
K(1)1-74 Fall "74"	0-14	2	5	5	35	29	0	0	2.11	2.13	35	34	0	0	10.7
K(1)1-74 Winter "75"	0-14	2	5	5	34	32	0	0	1.93	1.69	35	30	0	0	10.7

TABLE 9 Continued GREENHOUSE DATA FOR UTAH SITE

Sample No.	Depth (in.)	Pot wt. (Kg)	Germination: Days After Seeding for Ten Plants to Emerge I	Germination: Days After Seeding for Ten Plants to Emerge II	Germination: No. of Seeds Germinated I	Germination: No. of Seeds Germinated II	Salt Crust at Germination	Salt Crust at Harvest	Harvest: Plant Dry Weight (gm) I	Harvest: Plant Dry Weight (gm) II	Harvest: Avg. Plant Height (cm) I	Harvest: Avg. Plant Height (cm) II	Black Leaf Tips	Soil Surface Cracks	Field Cap. %
K(103)1-74	61.6- 68.2	2	9	9	31	31	0	0	0.33	0.40	13	17	0	4	13.4
K(103)2-74	125.1-135.1	2	9	9	30	27	0	0	0.29	0.28	16	14	0	4	18.0
K(103)3-74	177.2-185.3	2	7	7	30	33	0	0	0.48	0.55	19	20	0	2	14.6
K(105)1-74	65.0- 76.4	2	7	7	34	33	1	1	1.27	1.23	26	26	1	0	18.3
K(105)2-74	76.4- 90.8	2	6	6	35	34	0	0	1.27	1.68	30	30	2	0	16.9
K(105)3-74	90.8-109.8	2	5	*	32	*	0	0	2.15	*	34	*	0	0	27.8
K(105)4-74	109.8-116.9	2	5	5	33	32	2	3	2.60	2.37	33	37	0	0	42.5
K(105)5-74	116.9-122.7	2	5	5	31	34	1	1	2.57	2.22	38	23	0	3	25.8
K(105)6-74	122.7-127.7	2	5	5	33	32	0	0	2.05	2.28	34	36	0	2	24.7
K(105)7-74	127.7-131.6	2	7	5	32	33	0	0	2.78	2.37	22	36	0	3	23.6
K(105)8-74	131.6-136.4	2	7	5	35	32	0	0	1.75	2.34	34	37	0	3	30.4
K(105)9-74	136.4-141.1	2	5	5	31	33	1	0	1.78	1.36	34	33	0	4	27.8
K(105)10-74	141.1-147.8	2	5	6	30	31	1	0	1.93	2.30	34	36	0	4	34.2
K(105)11-74	147.8-153.0	1.9	5	6	32	31	1	2	2.45	2.74	41	41	0	4	37.6
K(105)12-74	153.0-160.7	2	5	5	32	34	0	1	2.29	2.64	38	41	0	3	34.6
K(105)13-74	160.7-164.5	2	7	8	32	23	0	0	1.06	1.02	27	36	0	0	13.8
K(105)14-74	164.5-169.0	2	7	*	26	*	0	0	0.37	*	15	*	0	0	8.1
K(105)15-74	188.5-191.0	2	5	5	29	29	0	2	2.72	2.91	38	40	0	1	28.7
K(105)16-74	191.0-196.7	2	5	5	31	32	0	0	1.15	2.72	25	41	0	2	33.9
K(105)17-74	196.7-205.5	2	5	5	29	32	0	0	2.77	2.34	38	36	0	2	27.8

* Sample enough for only one pot.

Table 9 Continued GREENHOUSE DATA FOR STANDARD SOIL

Sample No.	Depth (ft.)	Pot wt. (Kg)	Germination: Days After Seeding for Ten Plants to Emerge I	Germination: Days After Seeding for Ten Plants to Emerge II	Germination: No. of Seeds Germinated I	Germination: No. of Seeds Germinated II	Salt Crust at Germination	Salt Crust at Harvest	Harvest: Plant Dry Weight (gm) I	Harvest: Plant Dry Weight (gm) II	Harvest: Avg. Plant Height (cm) I	Harvest: Avg. Plant Height (cm) II	Black Leaf Tips	Soil Surface Cracks	Field Cap. %
Standard loam Soil Fall 1974		2	6	6	33	32	0	0	3.28	3.34	41	39	0	0	15.2
Standard loam Soil Winter 1975		2	6	6	35	33	0	0	3.20	2.84	36	36	0	0	15.2

Table 11

RANGE SITE 1 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Big sagebrush

DEPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	
10	0.0216	1.55	0.0	0.710	.268	.258	0.683	1.77	0.883	5.29	.142	0.116	.007	0.339	7.30	3.88	45.	.538	0.605	0.951
20	0.0337	1.57	1.56	0.702	.265	.236	0.625	1.83	0.790	4.67	.133	0.102	.020	0.330	7.33	1.87	65.	.489	0.552	0.541
30	0.0480	1.56	1.56	0.699	.264	.221	0.586	1.89	0.712	4.16	.144	0.078	.013	0.278	7.40	1.26	110.	.590	0.490	0.371
40	0.0435	1.61	1.58	0.678	.255	.214	0.557	1.89	0.702	3.86	.114	0.100	.0	0.203	7.39	0.32	95.	.433	0.505	0.419
	0.0367	1.57		0.697		.232		1.84		4.49	.133		.010	0.287	7.35			.513	0.539	0.599
50	0.0459	1.52	1.56	0.695	.262	.218	0.579	1.90	0.699	3.91	.123	0.096	.027	0.205	7.50	0.21	115.	.402	0.485	0.353
60	0.0379	2.16	1.76	0.504	.190	.193	0.512	1.90	0.664	4.03	.107	0.086	.007	0.189	7.41	0.34	90.	.255	0.512	0.404
70	0.0400	1.55	1.78	0.492	.186	.204	0.540	1.91	0.670	3.84	.104	0.100	.007	0.164	7.48	0.12	58.	.328	0.567	0.565
	0.0413	1.78		0.563		.205		1.90		3.93	.111		.013	0.186	7.46			.329	0.521	0.475
80	0.0319	1.73	1.85	0.435	.164	.186	0.493	1.87	0.680	2.30	.051	0.135	.0	0.114	7.42	0.12	74.	.381	0.535	0.473
90	0.0275	1.71	1.70	0.563	.212	.175	0.463	1.85	0.674	3.67	.067	0.107	.0	0.109	7.48	0.18	25.	.369	0.715	1.321
100	0.0477	1.69	1.78	0.492	.185	.206	0.546	1.89	0.691	3.68	.116	0.090	.013	0.192	7.33	0.79	85.	.444	0.518	0.454
110	0.0485	1.39	1.66	0.592	.223	.225	0.596	1.87	0.735	3.80	.124	0.101	.013	0.234	7.31	0.42	109.	.508	0.491	0.375
120	0.0443	1.53	1.60	0.551	.246	.199	0.529	1.85	0.719	3.73	.110	0.090	.007	0.189	7.30	0.44	104.	.514	0.496	0.353
130	0.0420	2.11	1.65	0.580	.219	.208	0.550	1.90	0.684	3.73	.105	0.103	.013	0.169	7.32	0.29	70.	.397	0.542	0.557
140	0.0404	1.92	1.85	0.431	.163	.220	0.582	1.85	0.738	3.64	.097	0.123	.013	0.150	7.33	0.30	71.	.485	0.540	0.564
150	0.0411	1.97	2.00	0.325	.123	.202	0.536	1.88	0.694	3.68	.100	0.102	.007	0.154	7.35	0.13	27.	.254	0.599	1.398
160	0.0419	1.59	1.83	0.452	.170	.198	0.525	1.87	0.698	3.71	.103	0.095	.013	0.159	7.34	0.32	65.	.494	0.562	0.567
170	0.0397	1.44	1.67	0.589	.222	.186	0.494	1.96	0.604	3.77	.100	0.086	.013	0.176	7.33	0.51	80.	.368	0.525	0.459
180	0.0354	1.40	1.61	0.646	.244	.156	0.412	1.92	0.595	3.55	.082	0.073	.0	0.088	7.33	0.10	60.	.226	0.562	0.514
190	0.0415	2.34	1.86	0.425	.161	.144	0.383	2.05	0.479	3.43	.092	0.052	.0	0.114	7.40	0.30	43.	.215	0.512	0.719
	0.0402	1.78		0.515		.192		1.90		3.56	.096		.008	0.154	7.35			.400	0.566	0.646
	0.0396	1.74		0.561		.203		1.89		3.81	.106		.009	0.187	7.37			.412	0.553	0.609

Table 11 Continued

KNAB SITE 2 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0354	0.71	0.0	2.725	****	.567	1.503	1.47	1.925	5.24	.219	0.348	.013	0.411	7.44	8.56	75.	.438	0.533	0.840
1		0.0354	0.71		2.725		.567		1.47		5.24	.219		.013	0.411	7.44			.438	0.533	0.840
	20	0.0759	0.65	0.68	2.899	****	.569	1.508	1.51	1.753	4.23	.239	0.330	.007	0.215	7.53	2.42	37.	.231	0.539	1.745
	30	0.0934	1.05	0.80	2.305	.870	.401	1.052	1.62	1.292	3.96	.255	0.146	.020	0.244	7.43	2.11	80.	.344	0.525	0.699
2		0.0852	0.85		2.602		.485		1.56		4.10	.247		.013	0.230	7.48			.288	0.582	1.218
	40	0.0711	1.12	0.94	1.928	.590	.294	0.778	1.77	0.937	4.07	.204	0.090	.007	0.223	7.39	3.06	27.	.272	0.699	1.755
	50	0.0459	2.03	1.40	0.995	.338	.198	0.524	1.90	0.671	3.90	.122	0.076	.0	0.189	7.42	0.97	12.	.291	0.927	3.121
	60	0.0612	0.96	1.37	0.935	.353	.265	0.702	1.89	0.773	3.90	.163	0.102	.0	0.188	7.42	0.57	39.	.369	0.529	1.194
3		0.0594	1.37		1.220		.252		1.85		3.96	.163		.002	0.200	7.41			.310	0.751	2.027
		0.0640	1.09		1.931		.382		1.69		4.22	.200		.008	0.245	7.44			.324	0.553	1.560

Table 11 Continued

KNAB SITE 3 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Juniper-Pinyon

M	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0162	0.91	0.0	1.900	.717	.301	0.798	1.68	1.053	5.51	.137	0.164	.013	0.325	7.31	3.57	22.	.535	0.745	2.090
	20	0.0400	1.04	0.98	1.717	.648	.295	0.781	1.72	0.995	4.70	.161	0.133	.033	0.289	7.33	0.86	42.	.562	0.515	1.105
	30	0.0480	1.05	1.00	1.551	.623	.279	0.740	1.83	0.853	4.36	.159	0.120	.020	0.284	7.38	0.36	22.	.548	0.745	2.150
1		0.0347	1.00		1.756		.292		1.74		4.86	.152		.022	0.299	7.34			.549	0.702	1.751
	40	0.0525	1.70	1.26	1.100	.415	.283	0.750	1.77	0.921	4.42	.179	0.104	.033	0.397	7.33	2.50	34.	.701	0.553	1.371
	50	0.0624	1.93	1.52	0.738	.279	.290	0.767	1.77	0.931	4.20	.191	0.099	.040	0.424	7.35	0.81	58.	.554	0.567	0.819
	60	0.0496	1.96	1.83	0.450	.170	.284	0.753	1.80	0.890	4.24	.155	0.129	.033	0.389	7.37	0.47	38.	.474	0.533	1.250
2		0.0549	1.93		0.763		.286		1.78		4.29	.175		.036	0.403	7.35			.575	0.518	1.146
	70	0.0587	2.10	1.96	0.350	.132	.295	0.783	1.80	0.907	4.28	.186	0.109	.020	0.352	7.45	0.53	39.	.599	0.629	1.255
	80	0.0525	2.16	2.07	0.279	.105	.245	0.650	1.85	0.784	4.25	.164	0.081	.020	0.346	7.38	0.84	50.	.580	0.589	0.859
	90	0.0584	1.61	1.96	0.354	.134	.270	0.714	1.88	0.789	4.15	.174	0.095	.033	0.346	7.40	0.79	45.	.716	0.505	1.059
	100	0.0576	1.64	1.80	0.469	.177	.305	0.808	1.79	0.932	4.15	.171	0.133	.033	0.305	7.40	0.61	47.	.700	0.598	1.062
	110	0.0592	0.96	1.41	0.885	.334	.307	0.814	1.74	0.991	4.24	.184	0.123	.033	0.351	7.40	1.02	53.	.595	0.580	0.913
	120	0.0631	1.03	1.21	1.187	.448	.305	0.808	1.75	0.976	4.13	.186	0.119	.033	0.358	7.36	0.53	47.	.603	0.598	1.031
3		0.0553	1.58		0.587		.288		1.80		4.20	.178		.029	0.343	7.40			.566	0.500	1.031
		0.0516	1.50		0.923		.288		1.78		4.38	.171		.029	0.347	7.37			.514	0.630	1.248

Table 11 Continued

KNAB SITE 4 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper

DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
10	0.0579	1.22	0.0	1.175	.443	.429	1.137	1.62	1.338	5.23	.355	0.074	.080	0.559	7.30	3.02	72.	.592	0.538	0.806
20	0.1053	1.11	1.16	1.276	.481	.498	1.319	1.62	1.450	4.43	.362	0.136	.133	0.601	7.20	0.57	65.	.544	0.552	0.999
	0.0816	1.16		1.225		.463		1.62		4.83	.358		.107	0.580	7.25			.568	0.545	0.897
30	0.1247	1.06	1.13	1.345	.508	.488	1.294	1.59	1.481	4.20	.381	0.108	.113	0.597	7.23	7.03	180.	.544	0.443	0.345
40	0.1145	1.92	1.36	0.946	.357	.468	1.241	1.62	1.402	4.04	.325	0.143	.080	0.638	7.26	9.18	84.	.589	0.520	0.732
50	0.0426	2.05	1.68	0.540	.219	.369	0.978	1.69	1.145	4.20	.252	0.117	.067	0.510	7.22	1.06	28.	.593	0.691	1.937
	0.1073	1.68		0.957		.442		1.63		4.15	.319		.087	0.582	7.24			.542	0.551	1.005
50	0.0875	1.40	1.79	0.479	.181	.409	1.084	1.65	1.263	4.03	.247	0.162	.067	0.463	7.28	0.51	26.	.789	0.707	2.199
70	0.1039	1.60	1.69	0.572	.216	.437	1.159	1.57	1.425	4.18	.315	0.123	.080	0.566	7.28	0.83	28.	.784	0.691	2.035
80	0.1343	1.31	1.44	0.844	.319	.506	1.340	1.58	1.525	4.07	.386	0.120	.120	0.667	7.25	0.43	25.	.743	0.715	2.534
90	0.1154	1.11	1.34	0.979	.369	.453	1.201	1.63	1.363	4.10	.338	0.115	.080	0.605	7.30	0.21	8.	.516	1.107	7.575
	0.1106	1.36		0.719		.451		1.61		4.10	.321		.087	0.575	7.28			.708	0.805	3.586
100	0.0662	2.58	1.66	0.592	.223	.265	0.703	1.88	0.784	4.15	.197	0.068	.0	0.347	7.23	0.21	5.	.150	1.431	9.380
	0.0662	2.58		0.592		.265		1.88		4.15	.197		.0	0.347	7.23			.150	1.431	9.380
	0.0994	1.54		0.879		.432		1.64		4.26	.316		.082	0.555	7.26			.524	0.740	2.853

Table 11 Continued

KNAB SITE 5 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Big sagebrush-Juniper

DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
10	0.0283	1.22	0.0	1.174	.443	.327	0.868	1.63	1.158	5.19	.168	0.160	.013	0.265	7.36	2.96	39.	.560	0.529	1.229
20	0.0938	1.95	1.58	0.572	.254	.431	1.143	1.63	1.327	4.46	.328	0.104	.093	0.394	7.27	3.00	229.	.935	0.424	0.255
30	0.0983	2.11	1.76	0.505	.190	.401	1.052	1.65	1.250	4.30	.315	0.086	.107	0.627	7.27	0.83	200.	.578	0.435	0.291
	0.0735	1.76		0.783		.387		1.64		4.65	.270		.071	0.428	7.30			.724	0.495	0.588
40	0.0998	1.59	1.88	0.407	.154	.452	1.197	1.64	1.345	4.22	.307	0.144	.107	0.776	7.22	4.58	269.	.953	0.412	0.228
50	0.0950	1.68	1.79	0.477	.180	.473	1.255	1.61	1.425	4.24	.306	0.168	.120	1.256	7.20	0.18	125.	.560	0.477	0.493
60	0.0921	1.98	1.71	0.546	.206	.429	1.136	1.69	1.240	4.19	.280	0.148	.100	1.087	7.07	0.26	155.	.755	0.457	0.390
70	0.0985	1.94	1.83	0.448	.169	.443	1.173	1.72	1.223	4.17	.297	0.146	.107	1.689	7.10	0.53	254.	.755	0.415	0.248
	0.0971	1.77		0.469		.449		1.66		4.21	.298		.108	1.202	7.15			.781	0.440	0.339
80	0.1095	1.63	1.82	0.460	.174	.521	1.381	1.64	1.458	4.08	.316	0.205	.107	1.238	7.03	0.41	167.	.946	0.450	0.401
90	0.0970	1.93	1.83	0.445	.168	.417	1.105	1.70	1.209	3.81	.249	0.168	.100	1.121	7.03	0.23	140.	.857	0.466	0.425
100	0.0493	1.42	1.66	0.594	.224	.265	0.702	1.85	0.812	3.86	.129	0.136	.047	1.263	6.99	0.16	30.	.892	0.677	1.538
	0.0853	1.66		0.500		.401		1.73		3.92	.232		.084	1.207	7.02			.998	0.531	0.788
	0.0865	1.73		0.573		.416		1.68		4.25	.270		.090	0.971	7.15			.799	0.484	0.549

Table 11 Continued

DEPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
LAB SITE 6 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper-Gambel oak																				
10	0.0154	1.22	0.0	1.171	.442	.253	0.671	1.68	0.977	5.60	.148	0.105	.013	0.199	7.32	6.24	45.	.665	0.605	0.897
20	0.0475	1.51	1.36	0.943	.356	.274	0.725	1.69	1.009	4.78	.202	0.071	.027	0.270	7.30	4.45	51.	.741	0.585	0.845
30	0.0807	1.16	1.30	1.044	.394	.312	0.827	1.70	1.045	4.58	.228	0.084	.047	0.243	7.32	2.92	170.	.732	0.443	0.293
	0.0412	1.30		1.053		.280		1.69		4.99	.193		.029	0.237	7.31			.713	0.546	0.575
40	0.0677	1.54	1.40	0.890	.336	.293	0.776	1.75	0.958	4.30	.217	0.076	.040	0.227	7.31	0.87	75.	.695	0.533	0.531
50	0.0719	2.00	1.57	0.693	.261	.280	0.743	1.81	0.874	4.32	.233	0.047	.053	0.299	7.29	1.20	24.	.424	0.725	1.970
60	0.0449	1.44	1.79	0.480	.181	.305	0.809	1.74	0.988	4.33	.276	0.029	.053	0.272	7.35	0.38	39.	.361	0.629	1.245
	0.0748	1.79		0.688		.293		1.77		4.31	.242		.049	0.266	7.32			.493	0.629	1.282
70	0.1341	1.75	1.86	0.423	.160	.417	1.105	1.65	1.262	4.23	.416	0.001	.087	0.430	7.36	0.15	21.	.345	0.755	2.774
80	0.1017	1.35	1.65	0.607	.229	.345	0.914	1.79	0.991	4.43	.350	-.005	.033	0.395	7.30	0.13	20.	.122	0.769	2.735
	0.1179	1.55		0.515		.381		1.72		4.33	.383		.060	0.412	7.33			.233	0.762	2.755
	0.0730	1.55		0.781		.310		1.73		4.57	.259		.044	0.292	7.32			.511	0.631	1.423

Table 11 Continued

KNAB SITE 7 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper-Mountain mahogany

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0662	0.92	0.0	1.868	.705	.554	1.467	1.51	1.727	5.55	.594	-.041	.100	0.731	7.19	6.66	91.	.413	0.510	0.704
	20	0.1150	1.26	1.09	1.432	.540	.498	1.319	1.55	1.560	4.84	.517	-.019	.120	0.729	7.20	3.43	120.	.752	0.481	0.512
	30	0.1271	1.41	1.20	1.215	.459	.516	1.358	1.58	1.543	4.58	.477	0.039	.133	0.903	7.25	3.41	93.	.769	0.509	0.590
1		0.1031	1.20		1.505		.522		1.55		4.99	.529		.118	0.787	7.21			.545	0.500	0.636
	40	0.1429	1.47	1.51	0.753	.284	.537	1.422	1.59	1.561	4.38	.477	0.060	.140	0.887	7.12	1.92	83.	.568	0.521	0.795
	50	0.1548	1.48	1.59	0.669	.253	.622	1.648	1.55	1.773	4.10	.452	0.170	.187	0.871	7.18	1.81	503.	.903	0.370	0.141
	60	0.1807	1.43	1.59	0.664	.250	.616	1.634	1.55	1.764	4.13	.533	0.084	.140	0.814	7.11	11.24	417.	.709	0.392	0.159
	70	0.1591	1.64	1.51	0.750	.283	.609	1.615	1.58	1.699	4.24	.495	0.115	.180	1.330	7.19	1.03	376.	.560	0.388	0.189
2		0.1594	1.60		0.709		.596		1.57		4.21	.489		.162	0.975	7.15			.710	0.415	0.324
	80	0.1626	1.55	1.54	0.723	.273	.629	1.657	1.54	1.803	4.30	.523	0.106	.193	1.543	7.10	0.68	339.	.488	0.395	0.209
	90	0.1647	1.57	1.62	0.636	.240	.612	1.622	1.55	1.738	4.17	.495	0.117	.173	2.525	7.03	0.29	174.	.463	0.445	0.405
	100	0.1637	1.34	1.52	0.742	.280	.589	1.560	1.53	1.752	4.16	.490	0.099	.173	2.427	7.08	0.86	129.	.569	0.474	0.525
	110	0.1646	1.52	1.54	0.716	.270	.570	1.511	1.58	1.634	4.13	.485	0.085	.173	2.717	7.07	0.17	214.	.735	0.429	0.319
	120	0.1642	2.03	1.66	0.593	.224	.547	1.451	1.57	1.612	4.23	.509	0.039	.160	2.525	7.11	0.40	148.	.747	0.461	0.445
	130	0.1696	1.61	1.75	0.513	.194	.577	1.528	1.55	1.678	4.17	.511	0.065	.173	2.941	7.03	0.16	117.	.527	0.484	0.541
	140	0.1669	1.58	1.84	0.441	.167	.572	1.517	1.55	1.688	4.14	.495	0.077	.167	2.500	7.10	0.20	108.	.499	0.492	0.520
	150	0.1735	1.64	1.71	0.551	.208	.627	1.660	1.53	1.817	4.14	.515	0.111	.187	2.427	7.11	0.07	100.	.864	0.500	0.701
	160	0.1730	1.68	1.80	0.471	.178	.614	1.628	1.52	1.814	4.18	.523	0.091	.173	1.786	7.22	0.28	117.	.819	0.484	0.585
	170	0.1755	1.67	1.73	0.531	.200	.649	1.721	1.52	1.875	4.13	.521	0.129	.193	1.825	7.15	0.18	178.	.711	0.444	0.400
	180	0.1755	1.64	1.73	0.530	.200	.606	1.605	1.53	1.781	4.11	.513	0.092	.193	1.812	7.20	0.15	180.	.809	0.443	0.391
	190	0.1715	1.63	1.71	0.547	.206	.650	1.723	1.51	1.896	4.15	.511	0.139	.187	2.451	7.12	0.18	115.	.752	0.485	0.513
	200	0.1677	1.58	1.78	0.486	.184	.588	1.557	1.54	1.732	4.10	.489	0.099	.173	2.155	7.10	0.45	139.	.727	0.467	0.484
	210	0.1646	1.68	1.80	0.474	.179	.619	1.641	1.54	1.787	4.15	.491	0.128	.193	1.761	7.09	0.14	95.	.789	0.505	0.737
	220	0.1655	1.71	1.76	0.506	.191	.571	1.514	1.53	1.721	4.22	.510	0.061	.180	2.066	7.10	0.11	193.	.701	0.438	0.343
	230	0.1655	1.45	1.62	0.641	.242	.618	1.637	1.54	1.784	4.18	.504	0.113	.180	1.786	7.10	0.13	203.	.744	0.433	0.345
3		0.1682	1.69		0.569		.602		1.54		4.17	.505		.180	2.203	7.11			.591	0.461	0.481
		0.1581	1.61		0.715		.591		1.55		4.28	.506		.168	1.805	7.13			.588	0.458	0.474

Table 11 Continued

KNAB SITE 8 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Juniper-Pinyon

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0169	1.09	0.0	1.434	.541	.260	0.688	1.71	0.952	5.62	.167	0.093	.013	0.321	7.38	3.80	15.	.592	0.850	2.789
	20	0.0488	1.45	1.27	1.091	.412	.331	0.876	1.65	1.137	4.91	.228	0.102	.033	0.523	7.33	2.25	26.	.590	0.707	1.882
	30	0.0679	1.52	1.35	0.961	.363	.326	0.864	1.65	1.130	4.50	.243	0.083	.040	0.559	7.33	1.21	44.	.724	0.508	1.101
	40	0.0772	1.37	1.45	0.833	.314	.354	0.939	1.70	1.111	4.40	.262	0.092	.053	0.619	7.32	1.34	41.	.588	0.620	1.294
1		0.0527	1.36		1.080		.318		1.68		4.86	.225		.035	0.506	7.34			.573	0.595	1.765
	50	0.0733	1.42	1.44	0.843	.318	.333	0.893	1.71	1.065	4.45	.255	0.078	.067	0.583	7.33	1.13	58.	.542	0.557	0.880
	60	0.0741	1.41	1.40	0.893	.337	.338	0.895	1.66	1.136	4.43	.255	0.083	.060	0.543	7.31	0.49	50.	.589	0.589	1.001
	70	0.0855	1.34	1.39	0.910	.343	.358	0.950	1.69	1.130	4.35	.283	0.076	.080	0.508	7.39	0.50	23.	.575	0.734	2.313
	80	0.0844	1.45	1.40	0.897	.338	.352	0.932	1.72	1.083	4.42	.289	0.063	.067	0.518	7.35	0.29	65.	.619	0.550	0.809
	90	0.0818	1.47	1.42	0.868	.327	.365	0.967	1.72	1.103	4.40	.276	0.089	.067	0.483	7.40	0.43	55.	.551	0.575	0.998
2		0.0799	1.42		0.882		.349		1.70		4.41	.272		.068	0.527	7.36			.595	0.503	1.200
	100	0.0823	1.17	1.37	0.941	.355	.357	0.945	1.71	1.102	4.37	.275	0.082	.067	0.490	7.32	0.53	33.	.450	0.559	1.622
	110	0.1011	1.09	1.25	1.126	.425	.422	1.119	1.65	1.270	4.42	.346	0.076	.087	0.676	7.28	0.15	28.	.494	0.591	2.096
3		0.0917	1.13		1.034		.389		1.68		4.40	.310		.077	0.583	7.30			.472	0.575	1.859
		0.0721	1.34		0.982		.345		1.69		4.57	.262		.059	0.529	7.34			.501	0.550	1.526

Table 11 Continued

KNAB SITE 9 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0150	1.45	0.0	0.829	.313	.250	0.662	1.76	0.882	5.47	.121	0.129	.007	0.184	7.53	3.01	58.	.516	0.567	0.724
	20	0.0484	0.93	1.19	1.228	.463	.353	0.935	1.70	1.109	4.90	.318	0.034	.040	0.403	7.38	1.19	70.	.438	0.542	0.750
1		0.0417	1.19		1.029		.301		1.73		5.19	.220		.023	0.294	7.45			.477	0.555	0.737
	30	0.1170	1.24	1.20	1.199	.453	.437	1.158	1.62	1.351	4.59	.442	-.005	.093	0.568	7.30	0.88	131.	.573	0.472	0.449
	40	0.1445	1.42	1.20	1.217	.459	.474	1.255	1.58	1.472	4.45	.502	-.028	.107	0.636	7.29	0.75	65.	.590	0.552	0.933
2		0.1308	1.33		1.208		.455		1.60		4.52	.472		.100	0.602	7.29			.581	0.512	0.691
	50	0.1362	1.12	1.26	1.106	.417	.525	1.391	1.54	1.624	4.54	.498	0.027	.107	0.628	7.29	0.68	141.	.550	0.465	0.449
3		0.1362	1.12		1.106		.525		1.54		4.54	.498		.107	0.628	7.29			.550	0.465	0.449
		0.0962	1.23		1.116		.408		1.64		4.79	.376		.071	0.484	7.36			.533	0.520	0.661

Table 11 Continued

KNAB SITE 10 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Big sagebrush-Juniper

DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
10	0.0526	1.01	0.0	1.615	.609	.500	1.324	1.54	1.580	5.62	.520	-.021	.107	1.012	7.20	0.0	43.	.718	0.512	1.422
20	0.1010	1.25	1.13	1.341	.505	.539	1.429	1.62	1.514	5.05	.528	0.011	.140	0.923	7.40	0.0	119.	.724	0.482	0.569
30	0.1147	1.37	1.21	1.187	.448	.546	1.447	1.60	1.561	4.70	.465	0.081	.133	0.801	7.28	0.0	209.	.504	0.431	0.323
	0.0894	1.21		1.381		.528		1.59		5.12	.505		.127	0.912	7.29			.582	0.508	0.771
40	0.1129	1.92	1.51	0.751	.283	.522	1.384	1.62	1.490	4.77	.476	0.046	.135	0.899	7.29	0.0	231.	.759	0.423	0.284
50	0.1196	1.71	1.67	0.590	.223	.557	1.476	1.60	1.579	4.66	.471	0.086	.153	0.868	7.23	0.0	125.	.289	0.477	0.545
60	0.1214	1.39	1.67	0.585	.221	.544	1.441	1.59	1.573	4.61	.463	0.081	.140	0.776	7.30	0.0	2.	.541	3.322	33.421
70	0.1132	2.41	1.84	0.443	.167	.491	1.300	1.59	1.484	4.63	.437	0.054	.127	0.779	7.31	0.0	171.	.773	0.448	0.351
80	0.1260	0.92	1.57	0.684	.258	.576	1.527	1.57	1.661	4.58	.471	0.105	.133	0.731	7.40	0.0	114.	.560	0.485	0.500
	0.1185	1.67		0.611		.538		1.59		4.65	.464		.138	0.811	7.31			.594	1.031	7.043
90	0.1201	2.22	1.85	0.432	.163	.507	1.343	1.60	1.496	4.59	.452	0.055	.127	0.833	7.28	0.0	115.	.501	0.485	0.554
100	0.1214	1.20	1.45	0.831	.314	.552	1.463	1.54	1.671	4.68	.466	0.066	.133	0.839	7.23	0.0	92.	.457	0.509	0.711
110	0.1196	1.73	1.72	0.543	.205	.544	1.441	1.58	1.589	4.63	.463	0.081	.133	0.933	7.28	0.0	102.	.390	0.498	0.549
120	0.1248	1.58	1.54	0.724	.273	.565	1.497	1.58	1.625	4.69	.500	0.065	.133	1.087	7.20	0.0	910.	.459	0.338	0.075
130	0.1097	2.41	1.94	0.366	.138	.476	1.261	1.62	1.414	4.71	.446	0.030	.113	1.147	7.20	0.0	104.	.518	0.495	0.594
140	0.1201	1.66	1.92	0.383	.145	.530	1.406	1.61	1.519	4.66	.473	0.058	.140	1.282	7.24	0.0	61.	.456	0.560	1.090
150	0.1254	1.88	1.98	0.338	.127	.544	1.440	1.56	1.622	4.61	.479	0.064	.140	1.330	7.23	0.0	105.	.582	0.495	0.521
160	0.1216	1.68	1.74	0.525	.198	.537	1.422	1.55	1.627	4.50	.436	0.101	.127	1.330	7.20	0.0	92.	.561	0.509	0.701
170	0.1258	1.87	1.81	0.466	.176	.560	1.485	1.57	1.633	4.60	.488	0.072	.140	1.488	7.15	0.0	79.	.501	0.527	0.848
	0.1213	1.81		0.512		.535		1.58		4.63	.469		.132	1.141	7.22			.526	0.491	0.649
	0.1149	1.67		0.694		.535		1.58		4.72	.474		.133	1.003	7.26			.574	0.553	2.551

Table 11 Continued

CNAB	SITE	11	DATE: 7/15/74	SAMPLE NO. 1	VEGETATION TYPE: Juniper-Big sagebrush													
DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
10	0.0275	0.75	0.0	2.520	.951	.350	0.927	1.63	1.195	5.82	.402	-.052	.040	0.607	7.32	0.0	65.	.545	0.550	0.753
20	0.0471	1.07	0.91	1.903	.718	.453	1.200	1.55	1.484	5.34	.461	-.008	.057	0.751	7.27	0.0	53.	.523	0.580	1.087
30	0.0422	1.30	1.04	1.546	.583	.435	1.152	1.59	1.391	4.97	.403	0.032	.073	0.740	7.33	0.0	220.	.585	0.427	0.261
	0.0589	1.04		1.989		.412		1.59		5.38	.422		.060	0.699	7.31			.518	0.519	0.700
40	0.1002	1.39	1.25	1.115	.421	.436	1.155	1.63	1.334	4.56	.371	0.064	.080	0.641	7.30	0.0	196.	.455	0.435	0.301
50	0.1065	1.54	1.41	0.883	.333	.437	1.159	1.63	1.337	4.57	.395	0.041	.080	0.617	7.31	0.0	149.	.589	0.460	0.397
60	0.1045	1.43	1.45	0.825	.311	.425	1.125	1.63	1.315	4.50	.375	0.050	.060	0.571	7.29	0.0	139.	.445	0.467	0.417
70	0.1137	1.98	1.65	0.607	.229	.459	1.216	1.57	1.462	4.46	.398	0.061	.093	0.605	7.40	0.0	85.	.404	0.518	0.590
80	0.1330	1.34	1.58	0.674	.255	.444	1.178	1.69	1.265	3.90	.354	0.090	.100	0.592	7.32	0.0	87.	.458	0.515	0.713
90	0.1052	2.13	1.82	0.460	.173	.413	1.095	1.65	1.270	4.54	.385	0.029	.087	0.512	7.48	0.0	60.	.576	0.562	0.956
100	0.1165	1.70	1.72	0.538	.203	.450	1.193	1.64	1.343	4.52	.421	0.029	.093	0.526	7.50	0.0	45.	.417	0.505	1.349
	0.1114	1.64		0.729		.438		1.63		4.44	.386		.085	0.581	7.37			.505	0.509	0.599
110	0.1195	1.25	1.69	0.565	.213	.470	1.245	1.62	1.404	4.48	.420	0.050	.127	0.539	7.51	0.0	81.	.519	0.524	0.763
120	0.1092	1.85	1.60	0.657	.248	.447	1.185	1.66	1.310	4.49	.388	0.060	.100	0.495	7.50	0.0	110.	.517	0.490	0.556
130	0.1028	2.10	1.73	0.530	.200	.423	1.120	1.65	1.285	4.41	.349	0.073	.087	0.465	7.40	0.0	67.	.499	0.548	0.959
140	0.0930	1.99	1.95	0.362	.137	.400	1.060	1.67	1.221	4.42	.319	0.081	.080	0.440	7.40	0.0	57.	.575	0.570	0.997
150	0.1049	1.66	1.88	0.409	.154	.424	1.124	1.65	1.288	4.40	.355	0.069	.100	0.470	7.42	0.0	76.	.504	0.532	0.772
160	0.1106	1.71	1.75	0.512	.193	.435	1.152	1.63	1.333	4.36	.367	0.068	.107	0.484	7.40	0.0	82.	.475	0.523	0.718
	0.1065	1.74		0.506		.433		1.65		4.43	.366		.100	0.482	7.44			.548	0.531	0.779
170	0.1053	1.63	1.67	0.590	.223	.434	1.149	1.65	1.303	4.42	.361	0.073	.107	0.482	7.40	0.0	87.	.534	0.515	0.585
180	0.1019	0.59	1.31	1.023	.386	.457	1.212	1.64	1.355	4.44	.352	0.105	.107	0.417	7.49	0.0	127.	.301	0.475	0.472
	0.1035	1.11		0.807		.446		1.64		4.43	.356		.107	0.450	7.44			.467	0.495	0.578
	0.1002	1.52		0.873		.433		1.63		4.59	.382		.088	0.553	7.39			.535	0.515	0.709

Table 11 Continued

RWAB SITE 12 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper

M	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0450	0.69	0.0	2.836	****	.607	1.609	1.40	2.042	5.80	.629	-.022	.0	0.470	7.38	0.0	5.	.607	1.431	12.548
	20	0.0549	0.88	0.79	2.374	.896	.413	1.093	1.63	1.295	5.07	.292	0.120	.020	0.323	7.46	0.0	137.	.277	0.468	0.412
	30	0.0482	1.34	0.97	1.731	.653	.270	0.715	1.72	0.956	4.81	.210	0.060	.0	0.242	7.53	0.0	20.	.153	0.769	2.178
1		0.0494	0.97		2.314		.430		1.58		5.23	.377		.007	0.345	7.46			.346	0.889	5.046
		0.0494	0.97		2.314		.430		1.58		5.23	.377		.007	0.345	7.46			.346	0.889	5.046

Table 12a. --Horizon and Profile averages of hydrologic data for soils of Alton Study Area near Kanab, Utah

Site	H	Depth cm	pF	M	SMC	AMC	ΔM cc/cc	Vol. wt.	M use cm	EK	TR	IR	EC	Nat. cov.	RC	S.T. req.
1	1	40	4.49	.037	.232	.133	.087	1.57	3.48	.538	.513	.598	.287	----	1	1
	2	70	3.93	.041	.205	.111	.082	1.78	1.23	.521	.328	.475	.186	----	1	1
	3	190	3.56	.040	.192	.096	.071	1.78	1.70	.566	.400	.646	.154	----	1	1
	P	---	3.81	.040	.203	.106	----	1.74	6.41	.553	.412	.609	.187	18.7	1	1
2	1	10	5.24	.035	.567	.219	.051	.71	.51	.533	.438	.840	.411	----	2	2
	2	30	4.10	.085	.485	.247	.069	.85	.69	.582	.288	1.218	.230	----	3	2
	3	60	3.96	.059	.252	.163	.086	1.37	.52	.751	.310	2.027	.200	----	2	2
	P	---	4.22	.064	.382	.200	----	1.09	1.72	.658	.324	1.560	.245	45.5	2	2
3	1	30	4.86	.035	.292	.152	.066	1.00	1.98	.702	.549	1.781	.299	----	2	2
	2	60	4.29	.055	.286	.175	.140	1.83	2.11	.618	.576	1.146	.403	----	2	2
	3	120	4.20	.058	.288	.178	.122	1.58	1.46	.600	.666	1.031	.343	----	2	2
	P	---	4.38	.052	.288	.171	----	1.50	5.55	.630	.614	1.248	.347	19.7	2	2
4	1	20	4.83	.082	.463	.358	.144	1.16	2.87	.545	.668	.897	.580	----	4	2
	2	50	4.15	.107	.442	.319	.184	1.68	2.76	.551	.642	1.005	.582	----	3	2
	3	90	4.10	.111	.451	.321	.150	1.36	1.20	.805	.708	3.586	.575	----	3	2
	4	100	4.15	.066	.265	.197	.175	2.58	.35	1.431	.150	9.380	.347	----	2	2
	P	---	4.26	.099	.432	.316	----	1.54	7.18	.740	.624	2.853	.555	25.5	3	2
5	1	30	4.65	.074	.387	.270	.179	1.76	5.36	.496	.724	.588	.428	----	3	2
	2	70	4.21	.097	.449	.298	.198	1.77	3.96	.440	.781	.339	1.202	----	3	2
	3	100	3.92	.085	.401	.232	.145	1.66	.87	.531	.898	.788	1.207	----	2	2
	P	---	4.25	.086	.416	.270	----	1.73	10.19	.484	.799	.549	.971	27.0	3	2
6	1	30	4.99	.041	.280	.193	.100	1.30	3.00	.546	.713	.675	.237	----	2	2
	2	60	4.31	.075	.293	.242	.174	1.79	2.60	.629	.493	1.282	.266	----	2	2
	3	80	4.33	.118	.381	.383	.204	1.55	.82	.762	.733	2.755	.412	----	3	2
	P	---	4.57	.073	.310	.259	----	1.55	6.42	.631	.511	1.423	.292	57.5	2	2
7	1	30	4.99	.103	.522	.529	.248	1.20	7.44	.500	.645	.636	.787	----	5	3
	2	70	4.21	.159	.596	.489	.308	1.60	6.15	.415	.710	.324	.975	----	5	3
	3	230	4.17	.168	.602	.505	.335	1.69	10.73	.461	.691	.481	2.203	----	5	3
	P	---	4.28	.158	.591	.506	----	1.61	24.32	.458	.688	.474	1.805	14.8	5	3
8	1	40	4.86	.053	.318	.225	.137	1.36	5.47	.696	.673	1.766	.506	----	2	2
	2	90	4.41	.080	.349	.272	.172	1.42	4.31	.603	.595	1.200	.527	----	3	2
	3	110	4.40	.092	.389	.310	.157	1.13	.63	.675	.472	1.859	.583	----	3	2
	P	---	4.57	.072	.345	.262	----	1.34	10.41	.650	.601	1.526	.529	29.6	3	2
9	1	20	5.19	.042	.301	.220	.113	1.19	2.26	.555	.477	.737	.294	----	2	2
	2	40	4.52	.131	.455	.472	.236	1.33	2.36	.512	.581	.691	.602	----	4	2
	3	50	4.54	.136	.525	.498	.210	1.12	.42	.465	.550	.449	.628	----	5	3
	P	---	4.79	.096	.408	.376	----	1.23	5.04	.520	.533	.661	.484	51.3	3	3
10	1	30	5.12	.089	.528	.505	.239	1.21	7.18	.508	.682	.771	.912	----	5	3
	2	80	4.65	.119	.538	.464	.304	1.67	7.59	1.031	.594	.448	.811	----	5	3
	3	170	4.63	.121	.535	.469	.334	1.81	6.01	.491	.526	.649	1.141	----	5	3
	P	---	4.72	.115	.535	.474	----	1.67	20.78	.653	.574	.622	1.003	46.7	5	3
11	1	30	5.38	.059	.412	.422	.165	1.04	4.95	.519	.618	.700	.699	----	3	2
	2	100	4.44	.111	.438	.386	.242	1.64	8.46	.509	.506	.689	.581	----	3	2
	3	160	4.43	.106	.433	.366	.240	1.74	2.88	.531	.548	.779	.482	----	3	2
	4	180	4.43	.104	.446	.356	.149	1.11	.60	.495	.467	.578	.450	----	4	2
	P	---	4.59	.100	.433	.382	----	1.52	16.89	.516	.535	.709	.553	48.9	3	2
12	1	30	5.23	.049	.430	.377	.138	.97	4.13	.889	.346	5.046	.345	41.0	3	2
13	1	20	5.31	.015	.220	.096	.061	1.48	1.23	.981	.579	3.717	.115	----	1	1
	2	50	4.43	.055	.258	.189	.140	1.71	2.09	.601	.527	.995	.221	----	2	2
	P	---	4.78	.039	.243	.151	----	1.62	3.32	.753	.548	2.084	.179	44.7	2	2

H = Hydrologically defined horizons; the 1 horizon usually corresponds to the A horizon and the 2 to the B horizon; horizons 3 and 4 are defined strictly on their relationships to water.

P = Profile values.

Depth cm = Depth in centimetres to the bottom of the soil horizon or the maximum depth sampled.

pF = Average moisture retention force when sampled. Logarithm of the height in centimetres of a column of water requiring an equivalent force to support it.

M = Average moisture content when sampled.

SMC = Average saturation moisture capacity

AMC = Average adsorbed moisture capacity.

ΔM = Moisture use between field capacity and ultimate plant stress expressed as a volume ratio.

Vol. wt. = Average volume weight.

M Use = Computed moisture depletion for horizon. Profile value is the sum of the horizon values.

EK = Average erodibility constant.

TR = Average transportability ratio. Portion of soil particles passing a 0.25 mm sieve.

IR = Average minimum computed infiltration rate.

EC = Electrical conductivity of saturated paste.

Nat. cov. = Natural cover of live vegetation

RC = Revegetation textural classification
1 = Coarse soil - requires irrigatic
2 = Marginal sandy loam soil
3 = Optimum soil texture
4 = Marginal clay loam soil
5 = Clay soil requires surface treatment

ST req. = Surface treatment requirement such as Arcadia contour furrowing
1 = Probably little benefit
2 = Beneficial for erosion control
3 = Required for vegetation establishment

Table 12b .--Soil hydrologic properties.

KNAB SITE 4 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0579	1.22	0.0	1.175	.443	.429	1.137	1.62	1.338	5.23	.355	0.074	.080	0.559	7.30	3.02	72.	.592	0.538	0.806
	20	0.1053	1.11	1.16	1.276	.461	.498	1.319	1.62	1.450	4.43	.362	0.136	.133	0.601	7.20	0.57	65.	.544	0.552	0.988
1		0.0815	1.16		1.225		.463		1.62		4.83	.358		.107	0.580	7.25			.568	0.545	0.897
	30	0.1247	1.06	1.13	1.345	.508	.488	1.294	1.59	1.481	4.20	.381	0.108	.113	0.597	7.23	7.03	180.	.544	0.443	0.345
	40	0.1146	1.92	1.36	0.946	.357	.468	1.241	1.62	1.402	4.04	.325	0.143	.080	0.638	7.26	9.18	84.	.588	0.520	0.732
	50	0.0425	2.05	1.68	0.580	.219	.369	0.978	1.69	1.146	4.20	.252	0.117	.067	0.510	7.22	1.06	28.	.693	0.691	1.937
2		0.1073	1.68		0.957		.442		1.63		4.15	.319		.087	0.582	7.24			.642	0.551	1.005
	60	0.0875	1.40	1.79	0.479	.181	.409	1.084	1.65	1.263	4.03	.247	0.162	.067	0.463	7.28	0.51	26.	.789	0.707	2.199
	70	0.1039	1.40	1.64	0.572	.215	.437	1.159	1.57	1.426	4.18	.315	0.123	.080	0.566	7.28	0.83	28.	.784	0.691	2.035
	80	0.1343	1.31	1.44	0.844	.319	.506	1.340	1.58	1.525	4.07	.386	0.120	.120	0.667	7.26	0.43	25.	.743	0.715	2.534
	90	0.1154	1.11	1.34	0.979	.369	.453	1.201	1.63	1.363	4.10	.338	0.115	.080	0.605	7.30	0.21	8.	.516	1.107	7.576
3		0.1106	1.36		0.719		.451		1.61		4.10	.321		.087	0.575	7.28			.708	0.805	3.586
	100	0.0662	2.58	1.68	0.592	.223	.265	0.703	1.88	0.784	4.15	.197	0.068	.0	0.347	7.23	0.21	5.	.150	1.431	9.380
4		0.0662	2.58		0.592		.265		1.85		4.15	.197		.0	0.347	7.23			.150	1.431	9.380
		0.0994	1.54		0.879		.432		1.64		4.26	.316		.082	0.555	7.26			.624	0.740	2.853

Table 12b .--Soil hydrologic properties.

AREA SITE 5 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Big sagebrush-Juniper

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0283	1.22	0.0	1.174	.443	.327	0.868	1.63	1.158	5.19	.168	0.160	.013	0.265	7.36	2.96	39.	.560	0.629	1.229
	20	0.0938	1.95	1.58	0.572	.254	.431	1.143	1.63	1.327	4.46	.328	0.104	.093	0.394	7.27	3.00	229.	.836	0.424	0.255
	30	0.0943	2.11	1.76	0.505	.190	.401	1.062	1.65	1.250	4.30	.315	0.086	.107	0.627	7.27	0.83	200.	.678	0.435	0.281
1		0.0735	1.76		0.783		.387		1.64		4.65	.270		.071	0.428	7.30			.724	0.496	0.588
	40	0.0995	1.59	1.85	0.407	.154	.452	1.197	1.64	1.346	4.22	.307	0.144	.107	0.776	7.22	4.58	269.	.953	0.412	0.226
	50	0.0980	1.68	1.79	0.477	.190	.473	1.255	1.61	1.425	4.24	.306	0.168	.120	1.256	7.20	0.18	125.	.560	0.477	0.493
	60	0.0921	1.68	1.71	0.546	.206	.429	1.136	1.69	1.240	4.19	.280	0.148	.100	1.087	7.07	0.26	155.	.755	0.457	0.390
	70	0.0985	1.94	1.83	0.448	.169	.443	1.173	1.72	1.223	4.17	.297	0.146	.107	1.689	7.10	0.53	254.	.755	0.416	0.248
2		0.0971	1.77		0.469		.449		1.66		4.21	.298		.108	1.202	7.15			.781	0.440	0.339
	80	0.1098	1.63	1.82	0.460	.174	.521	1.381	1.64	1.458	4.08	.316	0.205	.107	1.238	7.03	0.41	167.	.946	0.450	0.401
	90	0.0970	1.93	1.83	0.445	.169	.417	1.105	1.70	1.209	3.81	.249	0.168	.100	1.121	7.03	0.23	140.	.857	0.466	0.426
	100	0.0493	1.42	1.65	0.594	.224	.265	0.702	1.85	0.812	3.86	.129	0.136	.047	1.263	6.99	0.16	30.	.892	0.677	1.538
3		0.0853	1.66		0.500		.401		1.73		3.92	.232		.084	1.207	7.02			.898	0.531	0.788
		0.0865	1.73		0.573		.416		1.68		4.25	.270		.090	0.971	7.15			.799	0.484	0.549

Table 12b.--Soil hydrologic properties.

KNAB SITE 6 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper-Gambel oak

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0154	1.22	0.0	1.171	.442	.253	0.671	1.68	0.977	5.60	.148	0.105	.013	0.199	7.32	6.24	45.	.665	0.605	0.897
	20	0.0475	1.51	1.36	0.943	.356	.274	0.725	1.68	1.009	4.78	.202	0.071	.027	0.270	7.30	4.45	51.	.741	0.586	0.845
	30	0.0807	1.16	1.30	1.044	.394	.312	0.827	1.70	1.045	4.58	.228	0.084	.047	0.243	7.32	2.92	170.	.732	0.448	0.283
1		0.0412	1.30		1.053		.280		1.69		4.99	.193		.029	0.237	7.31			.713	0.546	0.575
	40	0.0677	1.54	1.40	0.890	.336	.293	0.776	1.75	0.958	4.30	.217	0.076	.040	0.227	7.31	0.87	75.	.695	0.533	0.631
	50	0.0719	2.00	1.57	0.693	.261	.280	0.743	1.81	0.874	4.32	.233	0.047	.053	0.299	7.29	1.20	24.	.424	0.725	1.970
	60	0.0849	1.84	1.79	0.480	.181	.305	0.809	1.74	0.988	4.33	.276	0.029	.053	0.272	7.35	0.38	39.	.361	0.629	1.246
2		0.0748	1.79		0.688		.293		1.77		4.31	.242		.049	0.266	7.32			.493	0.529	1.282
	70	0.1341	1.75	1.86	0.423	.160	.417	1.105	1.66	1.262	4.23	.416	0.001	.087	0.430	7.36	0.15	21.	.345	0.756	2.774
	80	0.1017	1.35	1.65	0.607	.229	.345	0.914	1.79	0.991	4.43	.350	-.005	.033	0.395	7.30	0.13	20.	.122	0.769	2.736
3		0.1179	1.55		0.515		.381		1.72		4.33	.383		.060	0.412	7.33			.233	0.762	2.755
		0.0730	1.55		0.781		.310		1.73		4.57	.259		.044	0.292	7.32			.511	0.631	1.423

Table 12b.--Soil hydrologic properties.

AVAS SITE 7 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper-Mountain mahogany

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	S/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0662	0.92	0.0	1.868	.705	.554	1.467	1.51	1.727	5.55	.594	-.041	.100	0.731	7.19	6.66	91.	.413	0.510	0.704
	20	0.1160	1.26	1.09	1.432	.540	.498	1.319	1.55	1.560	4.84	.517	-.019	.120	0.729	7.20	3.43	120.	.752	0.481	0.512
	30	0.1271	1.41	1.20	1.215	.459	.516	1.368	1.58	1.543	4.58	.477	0.039	.133	0.903	7.25	3.41	93.	.769	0.509	0.690
1		0.1031	1.20		1.505		.522		1.55		4.99	.529		.118	0.787	7.21			.545	0.500	0.636
	40	0.1429	1.57	1.51	0.753	.284	.537	1.422	1.59	1.561	4.38	.477	0.060	.140	0.887	7.12	1.92	83.	.568	0.521	0.795
	50	0.1548	1.48	1.59	0.669	.253	.622	1.648	1.55	1.773	4.10	.452	0.170	.187	0.871	7.18	1.81	503.	.903	0.370	0.141
	60	0.1807	1.43	1.59	0.664	.250	.616	1.634	1.55	1.764	4.13	.533	0.084	.140	0.814	7.11	11.24	417.	.709	0.382	0.169
	70	0.1591	1.64	1.51	0.750	.283	.609	1.615	1.58	1.699	4.24	.495	0.115	.180	1.330	7.19	1.03	376.	.560	0.388	0.189
2		0.1594	1.60		0.709		.596		1.57		4.21	.489		.162	0.975	7.15			.710	0.415	0.324
	80	0.1626	1.55	1.54	0.723	.273	.629	1.667	1.54	1.803	4.30	.523	0.106	.193	1.543	7.10	0.68	339.	.488	0.395	0.209
	90	0.1647	1.67	1.62	0.636	.240	.612	1.622	1.56	1.738	4.17	.495	0.117	.173	2.525	7.03	0.29	174.	.463	0.446	0.405
	100	0.1437	1.34	1.52	0.742	.280	.589	1.560	1.53	1.752	4.16	.490	0.099	.173	2.427	7.08	0.86	129.	.569	0.474	0.525
	110	0.1646	1.62	1.54	0.716	.270	.570	1.511	1.58	1.634	4.13	.485	0.085	.173	2.717	7.07	0.17	214.	.735	0.429	0.319
	120	0.1642	2.03	1.66	0.593	.224	.547	1.451	1.57	1.612	4.23	.509	0.039	.160	2.525	7.11	0.40	148.	.747	0.461	0.445
	130	0.1595	1.61	1.75	0.513	.194	.577	1.528	1.56	1.678	4.17	.511	0.065	.173	2.941	7.03	0.16	117.	.527	0.484	0.581
	140	0.1659	1.58	1.84	0.441	.167	.572	1.517	1.55	1.688	4.14	.495	0.077	.167	2.500	7.10	0.20	108.	.499	0.492	0.620
	150	0.1735	1.54	1.71	0.551	.205	.627	1.660	1.53	1.817	4.14	.515	0.111	.187	2.427	7.11	0.07	100.	.364	0.500	0.701
	160	0.1730	1.58	1.80	0.471	.175	.614	1.628	1.52	1.814	4.18	.523	0.091	.173	1.786	7.22	0.28	117.	.819	0.484	0.586
	170	0.1765	1.67	1.73	0.531	.200	.649	1.721	1.52	1.876	4.13	.521	0.129	.193	1.825	7.15	0.18	178.	.711	0.444	0.400
	180	0.1755	1.64	1.73	0.530	.200	.606	1.605	1.53	1.781	4.11	.513	0.092	.193	1.812	7.20	0.15	180.	.808	0.443	0.381
	190	0.1715	1.83	1.71	0.547	.205	.650	1.723	1.51	1.896	4.15	.511	0.139	.187	2.451	7.12	0.18	115.	.762	0.485	0.513
	200	0.1677	1.86	1.75	0.486	.184	.588	1.557	1.54	1.732	4.10	.489	0.099	.173	2.155	7.10	0.45	139.	.727	0.467	0.486
	210	0.1646	1.68	1.80	0.474	.179	.619	1.641	1.54	1.767	4.15	.491	0.128	.193	1.761	7.09	0.14	95.	.789	0.506	0.737
	220	0.1455	1.71	1.76	0.506	.191	.571	1.514	1.53	1.721	4.22	.510	0.061	.180	2.066	7.10	0.11	193.	.701	0.438	0.343
	230	0.1655	1.45	1.62	0.641	.242	.618	1.637	1.54	1.784	4.18	.504	0.113	.180	1.786	7.10	0.13	203.	.744	0.433	0.345
3		0.1682	1.69		0.569		.602		1.54		4.17	.505		.180	2.203	7.11			.691	0.461	0.481
		0.1581	1.61		0.715		.591		1.55		4.28	.506		.168	1.805	7.13			.588	0.458	0.474

Table 12b .--Soil hydrologic properties.

KNAB SITE 8 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Juniper-Pinyon

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0169	1.09	0.0	1.434	.541	.260	0.688	1.71	0.952	5.62	.167	0.093	.013	0.321	7.38	3.80	15.	.592	0.850	2.788
	20	0.0488	1.45	1.27	1.091	.412	.331	0.876	1.65	1.137	4.91	.228	0.102	.033	0.523	7.33	2.25	26.	.590	0.707	1.882
	30	0.0679	1.52	1.35	0.961	.363	.326	0.864	1.65	1.130	4.50	.243	0.083	.040	0.559	7.33	1.21	44.	.724	0.608	1.101
	40	0.0772	1.37	1.45	0.833	.314	.354	0.939	1.70	1.111	4.40	.262	0.092	.053	0.619	7.32	1.34	41.	.588	0.620	1.294
1		0.0527	1.36		1.080		.318		1.68		4.86	.225		.035	0.506	7.34			.673	0.696	1.766
	50	0.0733	1.42	1.44	0.843	.318	.333	0.883	1.71	1.066	4.45	.255	0.078	.057	0.583	7.33	1.13	58.	.642	0.567	0.880
	60	0.0741	1.41	1.40	0.893	.337	.338	0.895	1.66	1.136	4.43	.255	0.083	.060	0.543	7.31	0.49	50.	.589	0.589	1.001
	70	0.0855	1.34	1.39	0.910	.343	.358	0.950	1.69	1.130	4.35	.283	0.076	.080	0.508	7.39	0.50	23.	.575	0.734	2.313
	80	0.0844	1.45	1.40	0.897	.338	.352	0.932	1.72	1.083	4.42	.289	0.063	.067	0.518	7.35	0.29	66.	.619	0.550	0.809
	90	0.0818	1.47	1.42	0.868	.327	.365	0.967	1.72	1.103	4.40	.276	0.089	.067	0.483	7.40	0.43	55.	.551	0.575	0.998
2		0.0799	1.42		0.882		.349		1.70		4.41	.272		.068	0.527	7.36			.595	0.603	1.200
	100	0.0823	1.17	1.37	0.941	.355	.357	0.945	1.71	1.102	4.37	.275	0.082	.067	0.490	7.32	0.53	33.	.450	0.659	1.622
	110	0.1011	1.09	1.25	1.126	.425	.422	1.119	1.66	1.270	4.42	.346	0.076	.087	0.676	7.28	0.15	28.	.494	0.691	2.094
3		0.0917	1.13		1.034		.389		1.68		4.40	.310		.077	0.583	7.30			.472	0.675	1.859
		0.0721	1.34		0.962		.345		1.69		4.57	.262		.058	0.529	7.34			.601	0.650	1.526

Table 12b .--Soil hydrologic properties.

AREA SITE 9 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper

HORIZON	DEPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0150	1.45	0.0	0.929	.313	.250	0.662	1.76	0.882	5.47	.121	0.129	.007	0.184	7.53	3.01	58.	.516	0.567	0.724
	20	0.0484	0.93	1.19	1.228	.463	.353	0.935	1.70	1.109	4.90	.318	0.034	.040	0.403	7.38	1.19	70.	.438	0.542	0.750
1		0.0417	1.19		1.029		.301		1.73		5.19	.220		.023	0.294	7.45			.477	0.555	0.737
	30	0.1170	1.24	1.20	1.199	.453	.437	1.158	1.62	1.351	4.59	.442	-.005	.093	0.568	7.30	0.88	131.	.573	0.472	0.449
	40	0.1445	1.42	1.20	1.217	.459	.474	1.255	1.58	1.472	4.45	.502	-.028	.107	0.636	7.29	0.75	65.	.590	0.552	0.933
2		0.1308	1.33		1.208		.455		1.60		4.52	.472		.100	0.602	7.29			.581	0.512	0.691
	50	0.1362	1.12	1.26	1.106	.417	.525	1.391	1.54	1.624	4.54	.498	0.027	.107	0.628	7.29	0.68	141.	.550	0.465	0.449
3		0.1362	1.12		1.106		.525		1.54		4.54	.493		.107	0.628	7.29			.550	0.465	0.449
		0.0962	1.23		1.116		.408		1.64		4.79	.376		.071	0.484	7.36			.533	0.520	0.661

Table 12b .--Soil hydrologic properties.

KNAB SITE 10 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Big sagebrush-Juniper

H	DPTH	SM	VOL WT	VOL AVF	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0526	1.01	0.0	1.615	.609	.500	1.324	1.54	1.580	5.62	.520	-.021	.107	1.012	7.20	0.0	43.	.718	0.612	1.422
	20	0.1010	1.25	1.13	1.341	.505	.539	1.429	1.62	1.518	5.05	.528	0.011	.140	0.923	7.40	0.0	119.	.724	0.482	0.569
	30	0.1147	1.37	1.21	1.187	.445	.546	1.447	1.60	1.561	4.70	.465	0.081	.133	0.801	7.28	0.0	209.	.604	0.431	0.323
1		0.0894	1.21		1.381		.528		1.59		5.12	.505		.127	0.912	7.29			.682	0.508	0.771
	40	0.1129	1.92	1.51	0.751	.283	.522	1.384	1.62	1.490	4.77	.476	0.046	.136	0.899	7.29	0.0	231.	.769	0.423	0.286
	50	0.1196	1.71	1.67	0.590	.223	.557	1.476	1.60	1.579	4.66	.471	0.086	.153	0.868	7.23	0.0	125.	.289	0.477	0.545
	60	0.1214	1.39	1.67	0.585	.221	.544	1.441	1.59	1.573	4.61	.463	0.081	.140	0.776	7.30	0.0	2.	.541	3.322	33.421
	70	0.1132	2.41	1.84	0.443	.167	.491	1.300	1.59	1.484	4.63	.437	0.054	.127	0.779	7.31	0.0	171.	.773	0.448	0.361
	80	0.1260	0.92	1.57	0.684	.258	.576	1.527	1.57	1.661	4.58	.471	0.105	.133	0.731	7.40	0.0	114.	.560	0.485	0.600
2		0.1186	1.67		0.611		.538		1.59		4.65	.464		.138	0.811	7.31			.594	1.031	7.043
	90	0.1201	2.22	1.85	0.432	.163	.507	1.343	1.60	1.496	4.59	.452	0.055	.127	0.833	7.28	0.0	115.	.501	0.485	0.554
	100	0.1214	1.20	1.45	0.831	.314	.552	1.463	1.54	1.671	4.68	.466	0.066	.133	0.839	7.23	0.0	92.	.457	0.509	0.711
	110	0.1196	1.73	1.72	0.543	.205	.544	1.441	1.58	1.589	4.63	.463	0.081	.133	0.933	7.28	0.0	102.	.390	0.498	0.649
	120	0.1248	1.58	1.54	0.724	.273	.565	1.497	1.58	1.625	4.69	.500	0.065	.133	1.087	7.20	0.0	910.	.469	0.338	0.075
	130	0.1077	2.41	1.94	0.366	.138	.476	1.251	1.62	1.414	4.71	.446	0.030	.113	1.147	7.20	0.0	104.	.518	0.496	0.594
	140	0.1201	1.66	1.92	0.323	.145	.530	1.406	1.61	1.519	4.66	.473	0.058	.140	1.282	7.24	0.0	61.	.456	0.560	1.090
	150	0.1254	1.88	1.94	0.338	.127	.544	1.440	1.56	1.622	4.61	.479	0.064	.140	1.330	7.23	0.0	105.	.582	0.495	0.621
	160	0.1216	1.68	1.74	0.525	.198	.537	1.422	1.55	1.627	4.50	.436	0.101	.127	1.330	7.20	0.0	92.	.561	0.509	0.701
	170	0.1255	1.87	1.81	0.466	.175	.560	1.485	1.57	1.633	4.60	.488	0.072	.140	1.488	7.15	0.0	79.	.501	0.527	0.948
3		0.1213	1.81		0.512		.535		1.58		4.63	.469		.132	1.141	7.22			.526	0.491	0.649
		0.1149	1.67		0.694		.535		1.58		4.72	.474		.133	1.003	7.26			.574	0.653	2.551

Table 12D .--Soil hydrologic properties.

AREA SITE 11 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Juniper-Big sagebrush

H	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0275	0.75	0.0	2.520	.951	.350	0.927	1.63	1.195	5.82	.402	-.052	.040	0.607	7.32	0.0	66.	.546	0.550	0.753
	20	0.0671	1.07	0.91	1.903	.718	.453	1.200	1.55	1.484	5.34	.461	-.008	.067	0.751	7.27	0.0	53.	.523	0.580	1.087
	30	0.0822	1.30	1.04	1.546	.583	.435	1.152	1.59	1.391	4.97	.403	0.032	.073	0.740	7.33	0.0	220.	.585	0.427	0.261
1		0.0589	1.04		1.989		.412		1.59		5.38	.422		.060	0.699	7.31			.618	0.519	0.700
	40	0.1002	1.39	1.25	1.115	.421	.436	1.155	1.63	1.334	4.56	.371	0.064	.080	0.641	7.30	0.0	196.	.456	0.436	0.301
	50	0.1065	1.54	1.41	0.883	.333	.437	1.159	1.63	1.337	4.57	.396	0.041	.080	0.617	7.31	0.0	149.	.589	0.460	0.397
	60	0.1045	1.43	1.45	0.825	.311	.425	1.125	1.63	1.316	4.50	.375	0.050	.060	0.571	7.29	0.0	139.	.445	0.467	0.417
	70	0.1137	1.98	1.65	0.607	.229	.459	1.216	1.57	1.462	4.46	.398	0.061	.093	0.605	7.40	0.0	85.	.404	0.518	0.590
	80	0.1330	1.34	1.54	0.674	.255	.444	1.178	1.69	1.265	3.90	.354	0.090	.100	0.592	7.32	0.0	87.	.458	0.516	0.713
	90	0.1052	2.13	1.82	0.460	.173	.413	1.095	1.65	1.270	4.54	.385	0.029	.087	0.512	7.48	0.0	60.	.576	0.562	0.956
	100	0.1165	1.70	1.72	0.538	.203	.450	1.193	1.64	1.343	4.52	.421	0.029	.093	0.526	7.50	0.0	45.	.417	0.605	1.349
2		0.1114	1.64		0.729		.438		1.63		4.44	.386		.085	0.581	7.37			.505	0.509	0.689
	110	0.1155	1.25	1.69	0.555	.213	.470	1.245	1.62	1.404	4.48	.420	0.050	.127	0.539	7.51	0.0	81.	.518	0.524	0.763
	120	0.1072	1.85	1.60	0.657	.249	.447	1.185	1.66	1.310	4.49	.388	0.060	.100	0.495	7.50	0.0	110.	.517	0.490	0.556
	130	0.1024	2.10	1.73	0.530	.200	.423	1.120	1.65	1.285	4.41	.349	0.073	.087	0.465	7.40	0.0	67.	.499	0.548	0.869
	140	0.0930	1.49	1.95	0.362	.137	.400	1.060	1.67	1.221	4.42	.319	0.081	.080	0.440	7.40	0.0	57.	.576	0.570	0.997
	150	0.1049	1.66	1.84	0.469	.154	.424	1.124	1.65	1.288	4.40	.355	0.069	.100	0.470	7.42	0.0	76.	.504	0.532	0.772
	160	0.1105	1.71	1.75	0.512	.193	.435	1.152	1.63	1.333	4.36	.367	0.068	.107	0.484	7.40	0.0	82.	.476	0.523	0.718
3		0.1065	1.74		0.506		.433		1.65		4.43	.366		.100	0.482	7.44			.548	0.531	0.779
	170	0.1053	1.63	1.67	0.590	.223	.434	1.149	1.65	1.303	4.42	.361	0.073	.107	0.482	7.40	0.0	87.	.534	0.516	0.685
	180	0.1019	0.59	1.31	1.023	.385	.457	1.212	1.64	1.355	4.44	.352	0.105	.107	0.417	7.49	0.0	127.	.301	0.475	0.472
4		0.1035	1.11		0.807		.446		1.64		4.43	.356		.107	0.450	7.44			.467	0.495	0.578
		0.1002	1.52		0.873		.433		1.63		4.59	.382		.088	0.553	7.39			.535	0.515	0.709

Table 12b.--Soil hydrologic properties.

AREA SITE 12 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Pinyon-Juniper

M	DPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0450	0.69	0.0	2.836	****	.607	1.609	1.40	2.042	5.80	.629	-.022	.0	0.470	7.38	0.0	5.	.607	1.431	12.548
	20	0.0549	0.86	0.74	2.374	.896	.413	1.093	1.63	1.296	5.07	.292	0.120	.020	0.323	7.46	0.0	137.	.277	0.468	0.412
	30	0.0482	1.34	0.97	1.731	.653	.270	0.715	1.72	0.956	4.81	.210	0.060	.0	0.242	7.53	0.0	20.	.153	0.769	2.178
1		0.0494	0.97		2.314		.430		1.58		5.23	.377		.007	0.345	7.46			.346	0.889	5.046
		0.0494	0.97		2.314		.430		1.58		5.23	.377		.007	0.345	7.46			.346	0.889	5.046

Table 12b.--Soil hydrologic properties.

AREA SITE 13 DATE: 7/15/74 SAMPLE NO. 1 VEGETATION TYPE: Big sagebrush-Pinyon-Juniper

H	DEPTH	SM	VOL WT	VOL AVE	FVR	VMC	SMC	TVR	G/CC	SVR	PF	AMC	CMC	LS	EC	PH	ROOTS	ET	TRAN	EK	IR
	10	0.0070	1.70	0.0	0.561	.212	.209	0.554	1.78	0.800	5.69	.078	0.130	.0	0.099	7.74	0.0	6.	.548	1.285	6.121
	20	0.0237	1.27	1.48	0.767	.297	.230	0.610	1.77	0.842	4.93	.113	0.117	.013	0.132	7.62	0.0	30.	.510	0.577	1.312
1		0.0154	1.48		0.674		.220		1.77		5.31	.096		.007	0.115	7.68			.579	0.981	3.717
	30	0.0458	1.20	1.39	0.908	.343	.269	0.713	1.72	0.955	4.52	.170	0.099	.020	0.181	7.53	0.0	63.	.478	0.556	0.588
	40	0.0510	2.17	1.55	0.714	.270	.290	0.768	1.74	0.964	4.29	.194	0.096	.033	0.240	7.52	0.0	27.	.479	0.599	1.725
	50	0.0567	1.77	1.71	0.545	.206	.215	0.569	1.79	0.799	4.49	.202	0.013	.027	0.242	7.50	0.0	66.	.525	0.550	0.573
2		0.0545	1.71		0.722		.258		1.75		4.43	.189		.027	0.221	7.52			.527	0.601	0.995
		0.0390	1.62		0.703		.243		1.76		4.78	.151		.019	0.179	7.58			.548	0.753	2.084

Figure 1

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4002
Location: Pit No. 1
Description by: A. Dransfield, L. Stott.
Classification: Order-Entisols; Typic Ustifluvents, coarse, silty, mixed, (calcareous) mesic.
Vegetation: Sagebrush-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium, principally from sandstone and limestone. Topography: Gently sloping, 2%, alluvial bottom. Elevation: 6500 feet. Drainage: Well-drained. Runoff is rapid. Permeability is moderately rapid. Soil Moisture: Dry when sampled.
Remarks: This pit is in a large alluvial bottom. There are tremendous variations in this profile. Gravel seams occur on one side of the pit and not on the other. Large boulders are found at random in the pit, some in the gravel, and some in the soil materials.

HORIZON	DESCRIPTION
A1	0 to 15 inches, brown (7.5YR 5/3) sandy loam, brown to dark brown (7.5YR 4/2) moist; weak subangular blocky structure; slightly hard, friable; roots plentiful and medium; moderately effervescent; alluvium; moderate permeability.
C	15 to 25 inches, pale brown (10YR 6/3) fine sandy loam, less than 5% gravel, brown (10YR 5/3) moist; moderate subangular blocky structure; hard, friable; roots few and small; moderately effervescent; alluvium; moderate permeability.
C	25 to 41 inches, pale brown (10YR 6/3) sandy loam, less than 10% gravel, brown (10YR 5/3) moist; weak subangular blocky structure; slightly hard, friable; roots few and small; moderately effervescent; alluvium; moderate permeability.
C	41 to 47 inches, pale brown (10YR 6/3) fine sandy loam, 20% gravel, brown (10YR 5/3) moist; weak subangular blocky structure; very hard, friable; roots few and small; moderately effervescent; alluvium; moderate permeability.
C	47 to 52 inches, pinkish-gray to pink (7.5YR 7/3) gritty, fine sandy loam, brown (7.5YR 5/3) moist; moderate angular blocky structure; very hard, friable; roots none; moderately effervescent; alluvium; moderate permeability. No sample.
C	52 to 66 inches, brown (10YR 5/3) fine sandy loam, 10% gravel and cobble, brown to dark brown (10YR 4/3) moist; weak subangular blocky structure; slightly hard; roots few and small; moderately effervescent; few calcium mottlings on ped surfaces; alluvium; moderate permeability.
C	66 to 108 inches, light brown (7.5YR 6/4) fine sandy loam, 80% plus gravel, cobble, and stone; very hard; roots none; strongly effervescent; alluvium; moderate to rapid permeability.

C 108 to 132 inches, light brown (7.5YR 6/4) sandy loam, few gravel; weak subangular blocky structure; slightly hard, friable; roots none; strongly effervescent; alluvium; moderately rapid permeability.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4015
Location: Pit No. 2
Description by: A. Dransfield, L. Stott.
Classification: Order-Entisols; Typic Ustiorthent, loamy skeletal, mixed (calcareous) mesic.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: Ridgetop, 3-5% slope. Elevation: 6630 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.
Remarks: Surface is covered with gravel and cobble. The soil profile exposed in the pit is extremely variable. The described profile appears to be typical of the area. Numerous large stones were removed in excavating the pit. Some are greater than 24 inches in length along one axis.

HORIZON	DESCRIPTION
A1	0 to 6 inches, brown (7.5YR 5/4) gravelly, fine sandy loam (60% gravel), dark brown (7.5YR 3/2) moist; weak crumb structure; loose, friable; roots abundant small, medium, and large; moderately effervescent; alluvium; moderate permeability.
C	6 to 17 inches, pale brown (10YR 6/3) gravelly, fine sandy loam (80% gravel and cobble), brown to dark brown (10YR 4/3) moist; very hard, friable; roots plentiful and large; moderately effervescent; alluvium; moderate permeability.
C	17 to 38 inches, very pale brown (10YR 7/4) gravelly, fine sandy loam (90% gravel and cobble); moderate subangular blocky structure; slightly hard, friable; roots few and small; strongly effervescent; alluvium; moderate permeability.
C	38 to 68 inches, very pale brown (10YR 7/3) gritty, fine sandy loam, yellowish-brown (10YR 5/4) moist; moderate subangular blocky structure; soft, friable; calcium and manganese mottling on peds; abundant lime veining; roots few and small; strongly effervescent; alluvium; moderate permeability.
C	68 to 110 inches, gravelly loam (60-70% gravel); moderate subangular blocky structure; very hard, friable; calcium mottling common; roots plentiful and small; strongly effervescent; alluvium; moderate permeability.
C	110 to 130 inches, loam; weak subangular blocky structure; slightly hard, friable; calcium mottling common; roots few and small; strongly effervescent; alluvium; moderate permeability.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4006
Location: Pit No. 3
Description by: A. Dransfield, L. Stott.
Classification: Order-Mollisols; Pachic Argiustolls, fine-loamy, mixed mesic.
Vegetation: Juniper and dead sagebrush. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: Alluvial bottom. Less than 5% average slope. Elevation: 6580 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.
Remarks: The profile described as Pit No. 3 is typical of the exposed area within the entire pit. Surface drainage is rapid due to slope. There are few if any surface gravel in the immediate vicinity.

HORIZON	DESCRIPTION
A11	0 to 5 inches, brown (7.5YR 5/4) very fine, sandy loam, dark brown (7.5YR 3/2) moist; moderate crumb structure; soft, friable; roots abundant and small; not effervescent; alluvium; moderate permeability.
A12	5 to 10 inches, brown to dark brown (7.5YR 4/2) very fine sandy loam, dark brown (7.5YR 3/2) moist; weak subangular blocky structure; slightly soft, friable; roots plentiful and small; not effervescent; alluvium; moderate permeability.
B21t	10 to 17 inches, brown to dark brown (10YR 4/3) loam, dark brown (7.5YR 3/2) moist; strong subangular blocky structure; very hard, friable; roots abundant and medium; not effervescent; alluvium; moderately slow permeability.
B22t	17 to 34 inches, brown (7.5YR 5/4) loam, dark brown (7.5YR 3/2) moist; moderate subangular blocky structure; very hard, friable; roots plentiful and medium; not effervescent; alluvium; moderately slow permeability.
B23t	34 to 50 inches, brown (7.5YR 5/4) sandy clay loam, dark brown (7.5YR 3/2) moist; weak subangular blocky structure; very hard, friable; roots few and small; not effervescent; alluvium; moderately slow permeability.
Gravel	50 to 86 inches, yellowish-brown (7.5YR 6/6) gravelly sandy loam (90% gravel), brown to dark brown (7.5YR 4/4) moist; roots plentiful and medium; not effervescent; alluvium; rapid permeability. No sample. The gravels are comprised of quartz, sanstone and limestone.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4006
Location: Pit No. 4
Description by: A. Dransfield, L. Stott.
Classification: Order-Mollisols; Pachic Argiustolls, fine-loamy, mixed, mesic.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Elevation: 6570 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.
Remarks: Located on a gently sloping alluvial terrace.

HORIZON	DESCRIPTION
A1	0 to 2 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) moist; weak platy structure; soft, friable; roots few and small; not effervescent; alluvium; moderate permeability.
B1	2 to 8 inches, brown to dark brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) moist; strong granular structure; very hard, friable; roots abundant and large; not effervescent; alluvium; moderate permeability.
B21t	8 to 21 inches, brown (10YR 5/3) clay, dark brown (10YR 3/3) moist; moderate subangular blocky structure; very hard, friable; calcium mottling on subangular blocky peds; roots abundant and large; weakly effervescent; alluvium; moderate slow permeability.
B22tca	21 to 30 inches, brown (10YR 5/3) clay, dark brown (10YR 5/3) moist; moderate subangular blocky structure; very hard, friable; roots abundant and large; weak effervescence; calcium coating on faces of subangular blocky peds; alluvium; moderate slow permeability.
B23tca	30 to 38 inches, yellowish-brown (10YR 5/4) clay loam, brown to dark brown (10YR 4/3) moist; moderate prismatic; very hard, friable; weak effervescence; roots plentiful and medium; alluvium; moderate slow permeability.
D	38 inches plus, gravel and cobble.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4007
Location: Pit No. 5
Description by: A. Dransfield, L. Stott.
Classification: Order-Mollisols; Pachic Argiustolls, fine, mixed, mesic.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Elevation: 6550 feet. Drainage: Well-drained surface. Internal drainage is very slow. Soil Moisture: Dry when sampled.
Remarks: This pit was very hard to dig with the backhoe. Shale was encountered at 25 inches.

HORIZON	DESCRIPTION
A1	0 to 8 inches, brown (10YR 5/3) very fine sandy loam, dark brown (10YR 3/3) moist; weak subangular blocky structure; soft, friable; roots plentiful and medium; not effervescent; alluvium; moderate permeability.
B2t	8 to 25 inches, brown (10YR 5/3) clay, dark brown (10YR 3/3) moist; moderate prismatic structure breaking to subangular blocky; very hard, friable; roots plentiful and medium; not effervescent; alluvium; slow permeability.
C	25 to 56 inches, yellowish shale (loam); moderate angular blocky structure; very hard; calcium mottling is common; roots few and small; moderately effervescent; lacustrine; very slow permeability.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4001
Location: Pit No. 6
Description by: A. Dransfield, L. Stott.
Classification: Order-Alfisols; Typic Haplustalfs, fine, over-loamy skeletal, mixed, mesic.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: Gently sloping alluvial terrace. Elevation: 6590 feet. Drainage: Well-drained. Permeability is moderate. Soil Moisture: Dry when sampled.
Remarks: Profile described is typical of the entire area exposed in the pit. Stones as large as 15 inches along one axis were excavated. Limestone is dominant over sandstone in this profile.

HORIZON	DESCRIPTION
A1	0 to 4 inches, light yellowish-brown (10YR 6/4) very fine, sandy loam, brown to dark brown (7.5YR 4/4) moist; weak crumb structure; soft, friable; roots abundant and small; not effervescent; soil alluvium; moderate permeability.
B1	4 to 16 inches, strong brown (7.5YR 5/6) sandy clay loam, dark reddish-brown (5YR 3/4) moist; moderate subangular blocky structure; very hard, friable; not effervescent; roots abundant and large; alluvium; moderately slow permeability. Heavy root concentration at 16 inches.
B2t	16 to 30 inches, yellowish-red (5YR 4/6) sandy clay loam, dark reddish-brown (5YR 3/4) moist; moderate subangular blocky structure; very hard, firm; not effervescent; roots few and small; alluvium; moderately slow permeability.
D	30 to 90 inches, 90% gravel, cobble, and stone, pink (7.5YR 7/4) sandy loam, yellowish-red (5YR 4/6) moist, No sample.
D1	90 to 114 inches, weathered shale (silty clay), embedded weathered limestone; subangular blocky structure; very hard, firm; green, yellow, and brown mottling; strongly effervescent; marine; very slow permeability.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4017
Location: Pit No. 7
Description by: A. Dransfield, L. Stott.
Classification: Order-Entisols; Typic Ustorthent, fine, mixed, (calcareous) mesic.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Marine deposits. Topography: Steeply rolling. Elevation: 6580 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.
Remarks: The described profile is typical of the pit.

HORIZON	DESCRIPTION
A1	0 to 6 inches, light olive gray (5 Y 6/2) silty clay, gray (2.5YR 5/1) moist; moderate fine granular structure; hard, very sticky; roots abundant and medium; moderately effervescent; marine; very slow permeability. Weathered shale.
C	6 to 14 inches, light gray (10YR 7/1) silty clay; fine subangular blocky structure; very hard, very sticky; iron mottling common; roots plentiful and medium; moderately effervescent; lacustrine; very slow permeability.
C	14 to 22 inches, light gray (10YR 7/1) silty clay; moderate medium prismatic structure; very hard, very sticky; iron mottling common; roots plentiful and small; moderately effervescent; marine; very slow permeability.
C	22 to 38 inches, light gray (10YR 7/1) shale (silty clay); strong medium subangular blocky structure; very hard, very sticky; many iron mottlings; roots few and small; moderately effervescent; marine; very slow permeability. Note: Heavy root residues on ped faces. The color is (10YR 8/6) yellow. Also, very small crystal deposits (gypsum) along cleavage lines.
D Shale	38 to 120 inches, light gray (10YR 7/1) shale (silty clay); very strong, very coarse angular blocky structure; very hard; many iron mottlings; roots few and small; strongly effervescent; marine; very slow permeability. Note: Heavy root or plant residue. Color is reddish-brown. Roots are so fine they appear to be like pressed ferns. Gypsum (small crystals) lies along the cleavage planes.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4013
Location: Pit No. 8
Description by: A. Dransfield, L. Stott.
Classification: Order-Inceptisols; Udic Ustochrepts, coarse-silty, (non-calcareous) mixed, mesic.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: 4% SW slope. Elevation: 6550 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.
Remarks: Very uniform profile.

HORIZON	DESCRIPTION
A1	0 to 14 inches, pale brown (10YR 6/3) very fine sandy loam; weak subangular blocky structure; slightly hard, friable; roots plentiful and medium; not effervescent; moderate permeability.
B2	14 to 33 inches, light yellowish-brown (10YR 6/4) sandy clay loam; moderate subangular blocky structure; very hard, friable; roots plentiful and large; not effervescent; moderate permeability.
C	33 to 46 inches, light gray (10YR 7/2) weathered sandstone, (very fine sandy loam); massive structure; very hard, friable; roots plentiful and medium; not effervescent; moderate permeability. Note: Plant residue discoloration along cleavage planes. Residue color is 7.5YR 7/6, reddish-yellow.
C	46 to 59 inches, white (10YR 8/2) weathered sandstone, (very fine sandy loam); massive structure; very hard, friable; roots few and small; not effervescent; moderate permeability. Note: Very thin cemented seams--various angles. Organic discoloration along cleavage planes, reddish (5YR 6/6).
C	59 to 62 inches, brown clay loam; strong subangular blocky structure; very hard; roots few and small; not effervescent; moderate slow permeability. No sample.
C	62 to 106 inches, white (10YR 8/2) weathered sandstone, (very fine sandy loam); massive structure; very hard, friable; no roots observed; weakly effervescent; moderate slow permeability. Note: Very thin cemented seams--various angles. Compact when dry--takes water readily. Brown organic staining (7.5YR 5/4) along cleavage planes.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4008

Location: Pit No. 9

Description by: A. Dransfield, L. Stott.

Classification: Order-Mollisols; Typic Argiustolls, fine-loamy, mixed, mesic.

Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: Gentle 2-3% slope. Elevation: 6620 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.

Remarks: Description is typical of the profile exposed in this pit. Large cobble, stone, and boulders excavated beginning at 29 inches, some were about 36 inches long, some were rounded 18 x 18 inches. Between these large stones or boulders lay smaller cobble and gravel.

HORIZON	DESCRIPTION
A1	0 to 9 inches, brown (7.5YR 5/3) fine sandy loam, dark brown (7.5YR 3/2) moist; weak, fine platy structure; soft, friable; roots plentiful and small; not effervescent; alluvium; moderate permeability.
B1	9 to 16 inches, yellowish-red (5YR 5/6) silt loam; weak subangular blocky structure; very hard, friable; roots abundant and medium; not effervescent; alluvium; moderate permeability.
B2t	16 to 29 inches, red (2.5YR 4/6) clay loam; moderate subangular blocky structure; very hard, firm; roots abundant and medium; not effervescent; alluvium; moderate slow permeability.
D	29 to 108 inches, 90% gravel, cobble, stone, and boulders; 10% very gravelly, sandy loam. No sample.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4003
Location: Pit No. 10
Description by: A. Dransfield, L. Stott.
Classification: Order-Entisols; Vertic Ustifluvents, fine, montmorillomitic (noncalcareous) mesic.
Vegetation: Sage-juniper-oak. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: Gentle sloping bottom about 2% south facing. Elevation: 6590 feet. Drainage: Well-drained. Permeability is very slow. Soil Moisture: Dry when sampled.
Remarks: Description is typical of the profiles exposed. On the surface there are large cracks. Small gravels are scattered in the profile. Between 51 to 55 inches there are quite a few woody stems. Surface relief is gently sloping and the physiographic position is alluvial bottom. At this particular location the sage population is heavy.

HORIZON	DESCRIPTION
A1	0 to 9 inches, grayish-brown (10YR 5/2) silty clay loam, dark grayish-brown (10YR 4/2) moist; moderately fine crumb structure; soft, friable; strongly effervescent; roots abundant and large; alluvium; moderate slow permeability.
C1	9 to 25 inches, white (10YR 8/1) silty clay; moderately coarse prismatic; very hard; white root stains; roots plentiful and large; strongly effervescent; alluvium; slow permeability.
C2	25 to 55 inches, light gray (10YR 7/2) silty clay; strong medium subangular blocky structure; very hard; root staining along cleavage planes; roots few and small; strongly effervescent; alluvium; slow permeability. A few fine gravel, very moist when excavated.
C3	55 to 103 inches, light gray (7.5YR 7/1) silty clay; moderate medium subangular blocky structure; very hard; no roots observed; strongly effervescent; alluvium; slow permeability. Scattered gravel, assorted sizes--very moist when excavated.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4005
Location: Pit No. 11
Description by: A. Dransfield, L. Stott.
Classification: Order-Mollisols; Fluventic Haplustolls, fine-loam, mixed, mesic.
Vegetation: Sagebrush-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: 2% gentle slope, alluvial bottom. Elevation: 6550 feet. Drainage: Well-drained. Permeability is very slow. Soil Moisture: Dry when sampled.
Remarks: Description is typical of the exposed profile in this pit. Sagebrush is rapidly being crowded out by pinyon and juniper. To the south about 600 feet is a small playa lake which is almost nude of vegetation. It is 20 or 25 feet lower in elevation than this site.

HORIZON	DESCRIPTION
A1	0 to 7 inches, brown (10YR 5/3) silt loam, very dark grayish-brown (10YR 3/2) moist; moderate, fine, crumb structure; soft; roots abundant and medium; weakly effervescent; alluvium; moderate permeability.
C1	7 to 13 inches, light gray (10YR 7/2) clay loam; weak, fine, subangular blocky structure; hard; roots plentiful and medium; moderately effervescent; alluvium; moderate permeability.
C2	13 to 35 inches, light gray (10YR 7/2) clay loam; moderate, medium, subangular blocky structure; very hard; roots plentiful and small; strongly effervescent; alluvium; moderate slow permeability.
C3	35 to 74 inches, light gray (10YR 7/1) clay loam; moderate, medium, subangular blocky structure; very hard; calcium mottling common; roots few and small; very strongly effervescent; alluvium; moderate slow permeability.
C4	74 to 88 inches, light gray (7.5YR 7/1) loam; massive structure; very hard; calcium mottlings few; roots few and small; strongly effervescent; alluvium; moderate permeability.
D	88 to 136 inches, gravelly fine sandy loam (80% gravel).

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4015
Location: Pit No. 12
Description by: A. Dransfield, L. Stott.
Classification: Order-Entisols; Typic Ustorthent, fine-loamy, mixed, (calcareous) mesic.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: Ridgetop, gentle 3% slope at pit site. Elevation: 6650 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.
Remarks: Pit No. 12 is located on a ridge, dissected by erosion. The profile described is on the north wall of the pit; at the other end, or south wall, a distance of 12 feet, shale is exposed for the entire depth. Huge boulders were evacuated from this pit, 24 to 36 inches long and quite thick.

HORIZON	DESCRIPTION
A1	0 to 5 inches, light yellowish-brown (10YR 6/4) silt loam (20% gravel), dark grayish-brown (10YR 4/2) moist; weak, fine, crumb structure; soft, friable; roots abundant, medium, and large; moderately effervescent; alluvium; moderate permeability. Note: Heavy concentration of cobble and stone on surface.
C1	5 to 31 inches, white (7.5YR 8/1) loam to clay loam (25% gravel); weak subangular blocky structure; very hard; roots abundant and large; strongly effervescent; alluvium; moderate permeability. Note: Transported, weathered shale.
C2	31 to 150 inches, pink (7.5YR 8/4) cobbly, fine sandy loam, (50% cobble and stone); weak subangular blocky structure; very hard; calcium mottlings on ped faces; roots few and small; strongly effervescent; alluvium; moderate permeability.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4008
Location: Pit No. 13
Description by: A. Dransfield, L. Stott.
Classification: Order-Mollisols; Typic Argiustolls, fine-loamy, mixed, mesic.
Vegetation: Sagebrush, pinyon, juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Topography: Gentle 2% slope. Elevation: 6500 feet. Drainage: Well-drained. Soil Moisture: Dry when sampled.
Remarks: The profile described is typical of the entire exposure. Huge boulders were excavated from this pit, some of them 24 to 36 inches long, some are almost that thick.

HORIZON	DESCRIPTION
A1	0 to 9 inches, brown to dark brown (10YR 4/3) fine sandy loam, dark brown (7.5YR 3/2) moist; weak, fine, subangular blocky structure; soft; roots plentiful and medium; not effervescent; alluvium; moderate permeability.
B1	9 to 19 inches, brown (10YR 5/3) loam, very dark grayish-brown (10YR 3/2) moist; weak, fine, subangular blocky structure; hard; roots plentiful and medium; not effervescent; alluvium; moderate permeability.
B2t	19 to 34 inches, red (2.5YR 5/6) silty clay loam (15% gravel); moderate, medium, subangular blocky structure; very hard; roots few and medium; not effervescent; alluvium; moderate permeability.
D	34 to 118 inches, 80% gravel, cobble, and stone. Texture of soil material is sandy loam. No sample taken of this zone.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4004.
Description by: A. Dransfield.
Vegetation: Pinyon-juniper-oak. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Marine deposits, including sandstone and shale overlain by quaternary deposits of sand, gravel, and cobble where present. Topography: Steep slopes of 70% and greater, characterized by sharp ridgetops. Severely eroded. Elevation 6500 feet. Drainage: Well-drained. Runoff is rapid. Permeability is moderate.
Remarks: Soils in this association are confined to a very small acreage in the southeast corner of Section 17.

HORIZON	DESCRIPTION
A-C	This area is rough and broken. It is characterized by steep slopes and sharp ridgetops. Lying on the surface or embedded are huge sandstone boulders. Exposed also are sandstone ledges and shale. Although there is considerable difference in fine materials and in their depth over the more consolidated materials, a mantel of yellowish-brown, fine sandy loam several feet thick covers much of the area.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4009.
Description by: A. Dransfield.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium. Originating from higher lying quaternary deposits of sand, gravel, and cobble in the immediate vicinity. Topography: Steeply sloping. Slopes range from 25 to over 50%. They occupy the position between the pediment surfaces and the lower lying alluvial bottoms. Elevation: 6500-6800 feet. Drainage: Well-drained. Runoff is rapid. Soil Moisture: Dry when mapped.
Remarks: Sandstone and limestone gravel, cobble, stone, and boulders almost completely cover the surface of these slopes. These soils are closely related to soil association number 4014, except the shale layer was not encountered at depths probed using hand tools. Undoubtedly shale underlies these soils at relatively shallow depths. The profile description below is believed to predominate in this soil association. The site described has a 40% east slope. Ninety percent of the surface area is covered by gravel, cobble, stone, and boulders.

HORIZON	DESCRIPTION
A	0 to 7 inches, brown to dark brown (7.5YR 4/4) soft, gravelly (80% gravel) loam, dark brown (7.5YR 3/2) moist; crumb structure; soft; roots plentiful; moderately effervescent; alluvium; moderate to moderately rapid permeability.
C	7 to 30 inches, dark grayish-brown (10YR 4/4) gravelly loam, brown to dark brown (7.5YR 4/4) moist; (80% gravel and cobble, sandstone, limestone, and quartzite are abundant and occur in that order); subangular blocky structure; roots plentiful; moderately effervescent; alluvium; moderate to rapid permeability.
	Stopped at 30 inches because of difficult digging using hand tools. Profile appeared to continue the same.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4010.
Description by: A. Dransfield.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvium over shale at varying depths. Topography: Moderate to steeply sloping, 5-40% slopes. Elevation: 6500-6800 feet. Drainage: Well-drained. At this sampling site, small runoff drains occur about every 100 feet. Runoff is rapid. Permeability is moderately slow to moderate. Soil Moisture: Dry when sampled.
Remarks: At this site there is a 17% southeast slope. Ninety percent of the ground surface is covered with gravel and cobble. Embedded sandstone boulders larger than two-feet long are exposed at the surface. Pine needle accumulations to depths of six inches are found under the trees.

HORIZON	DESCRIPTION
A	0 to 5 inches, yellowish-brown (10YR 5/4) gravelly (40% gravel) light clay loam, brown to dark brown (10YR 4/3) moist; fine subangular blocky structure; soft; strongly effervescent; alluvium; moderate permeability.
C	5 to 11 inches, pale brown (10YR 6/3) gravelly (30% gravel) light clay, brown (10YR 5/3) moist; strong subangular blocky structure; strongly effervescent; alluvium; slow to moderately slow permeability. Parent material appears to have been alluvial shale material.
C	11 to 24 inches, very pale brown (10YR 7/3) gravelly (30% gravel) clay, pale brown (10YR 6/3) moist; strong subangular blocky structure; strongly effervescent; alluvium which appears to have developed from shale-like material; slow to moderately slow permeability.
	24 inches plus, hand tools stopped by gravel. It appears that the same type of material continues below the 24-inch depth.

COAL-MINE RECLAMATION STUDIES
KANAB, UTAH

Soil Association: 4014.
Description by: A. Dransfield.
Vegetation: Pinyon-juniper. Use: Livestock forage. Climate: Mean annual precipitation is about 16 inches. Mean annual air temperature 45.3°F, January 26.1°F, July 65.8°F. Parent Material: Alluvial surface soil material, transported from areas in the immediate vicinity above the slopes. Topography: Very steeply sloping; slopes from 25 to greater than 50% are most common. Elevation: 6400-6800 feet. Drainage: Well-drained. Runoff is rapid. Permeability is moderate. Soil Moisture: Dry when sampled.
Remarks: The soil profile was exposed for some distance on a 40% west slope. The variability in the thickness of the soil over shale ranged from less than 12 inches to over 36 inches. Typically the surface of this soil association has a very heavy gravel, cobble, stone, and boulder cover. Up to 90% of the surface area is covered by rock debris.

HORIZON	DESCRIPTION
A-C	0 to 24 inches, brown, gravel and cobbly (75% gravel and cobble) loam.
D	24 to 60 inches plus, shale. Very slowly permeable.

Figure 2

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature Coal Strip Mining Reclamation Project EMRIA (Energy Mineral Rehabilitation Inventory and Analysis) Hole No TP-1

Area Designation Alton Coal Field Coordinates 2200' N. & 1130' W. of SE Cor. Sec. 8, T. 40 S., R. 4-1/2 W. Ground Elevation 6620± Depth To Ground Water Level* None

Method of Excavation Back Hoe Approximate Dimensions of Hole 5' to 3' wide x 20' long Dates of Excavation 6/18/74 Hole Logged By Branstetter

CLASSIFICATION SYMBOL		DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS **				
LETTER	GRAPHIC				VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 8-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 8-INCH	WEIGHT OF PLUS 8-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 8-INCH
SM		0.0 2.0		Silty Sand: About 80% fine sand with trace of coarse sizes. About 20% slight to nonplastic fines. Moderately limy, brown in color. Top 10" damp from recent 3/4" rain. Few rootlets. Top soil.					
GM		2.0 to 11.4		Sandy Gravel: About 30% subangular limestone gravel in 1 to 3 foot lenses becoming more plentiful with depth. Mostly 1-1/2" sizes. About 55% fine sand with lenses of coarse sizes. About 15% nonplastic fines. About 15% (by volume) of subangular limestone cobbles to 18". Few rootlets to 7.0 feet depth. Materials are gray-brown in color, moderately limy and dry. Materials are derived as alluvium from reworked pediment deposits.					

REMARKS

Area has 2-1/2% grade to the south. The pit is about 150' west of Skutumpah Creek. Area is densely covered with sagebrush and moderately covered with 10 to 20' Junipers. Logged on 7/16/74.

NOTES Record water test and density test data, if applicable, under remarks

* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.

** Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** $\frac{\text{(Lbs of rock sampled) } 100}{\text{(Bulk specific gravity of rock, 62.4) (Cubic feet of hole sampled)}}$

Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841971

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature Coal Strip Mining Reclamation Project EMRIA Cor. Sec. 8, T. 40 S., R. 4-1/2 W. Hole No TP-2

Area Designation Alton Coal Field. Coordinates 1580' W, 200' N of SE/ Ground Elevation 6625± Depth To Ground Water Level * None

Method of Excavation Back Hoe Approximate Dimensions of Hole 6' to 3' wide x 16' long Dates of Excavation 6/18/74 Hole Logged By Praestgaard

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 9-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF 3 TO 9 INCH REMAINING	WEIGHT OF PLUS 9-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS 9 INCH
Sp		0.0 to 1.3		Gravelly Sand: About 55% poorly graded very fine sand with lesser amounts of coarse sand sizes. About 30% poorly graded subangular limestone gravel. About 15% of slightly plastic fines. Occasional 5 inch cobble. Materials are very limy. Many Juniper roots to 1-1/2 inches in size. Damp and dark brown color. Topsoil.					
GW		1.3 to 3.3		Well Graded Gravel: About 70% subangular sandstone and limestone gravel. About 30% fine sand with trace of slightly plastic fines. About 20% (by volume) cobbles to 14 inches of subangular limestone and sandstone. Materials are very limy, gravels and cobbles are mostly caliche coated. Dry and yellow-gray color. Pediment deposits.					
SC		3.3 to 5.5		Clayey Sand: About 80% poorly graded very fine sand. About 20% medium plastic fines. Section contains two bentonitic beds 2 to 8" thick that are highly to moderately plastic and white in color. The sand and fines are very limy, limonite stained and little chalky. Materials are dry to damp and yellow-brown color. Pediment deposits.					

REMARKS

NOTES Record water test and density test data, if applicable, under remarks
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** $\frac{\text{(Lbs of rock sampled) } 100}{\text{(Bulk specific gravity of rock) } 62.4 \text{ (Cubic feet of hole sampled)}}$
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

CONTINUED

CPO 861571

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature ..... Project ..... Hole No. TP-2

Area Designation ..... Coordinates ..... Ground Elevation ..... Depth To Ground Water Level * .....

Method of Excavation ..... Approximate Dimensions of Hole ..... Dates of Excavation ..... Hole Logged By .....

CLASSIFICATION SYMBOL		DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART "UNIFIED SOIL CLASSIFICATION" GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS **				
LETTER	GRAPHIC				VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
SP		5.5 to 11.5		Gravelly Sand: About 65% poorly graded fine sand with a few coarse sizes. About 25% subangular limestone and sandstone gravel mostly 1" size. About 10% slightly plastic fines. There are about 10% (by volume) sandstone and limestone cobbles to 15" size. Materials are very limy and many of the gravels are caliche coated. Dry to damp, few rootlets, buff color. Pediment deposits.					

REMARKS

Pit is located on a ridge about 125' wide with about 2% slope to the south. Area moderately covered with 20-25' Juniper and Pinon Pines. Logged on 7/19/74.

NOTES Record water test and density test data, if applicable, under remarks

* Record after water has reached its natural level, give date of reading adjacent to graphic symbol or in remarks.

** Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** $\frac{\text{(Lbs of rock sampled)} \times 100}{\text{(Bulk specific gravity of rock)} \times 62.4 \text{ (Cubic feet of hole sampled)}}$

Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation Project: EMRIA Cor. Sec. 8, T. 40 S., R. 4-1/2 W Hole No: TP-3
Area Designation: Alton Coal Field Coordinates: 2300' E, 100' N of SW/ Ground Elevation: 6595+ Depth To Ground Water Level*: None
Method of Excavation: Back Hoe Approximate Dimensions of Hole: 5' to 3' wide x 14' long Dates of Excavation: 6/18/74 Hole Logged By: Branstetter

CLASSIFICATION SYMBOL: LETTER	CLASSIFICATION SYMBOL: GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS **: VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH (%)	WEIGHT OF PLUS 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS 5-INCH (%)
Sm		0.0 to 1.5		Silty Sand: About 80% poorly graded fine to very fine sand. About 20% of nonplastic fines. Trace of subrounded igneous 1/2" gravel. Several Juniper roots throughout. Material is damp from recent rain. Dark brown color. Topsoil.					
Sm		1.5 to 4.2		Silty Sand: About 85% poorly graded fine sand. About 15% of nonplastic fines. Occasional subangular limestone gravel 3/4". Trace of rootlets. Material is dry and brown in color. Sub-soil.					
Gw-Gc		4.2 to 8.5		Sandy Gravel: About 70% well graded subrounded to subangular limestone and sandstone gravel. About 20% of fine sand and 10% of slightly plastic fines. Cobbles 15% (by volume) subangular limestone and cobbles. Materials are very limy with several rootlets in upper 2 feet. Rusty to yellow brown color and dry. Materials are alluvium, reworked pediment deposits.					

REMARKS

Pit is located in narrow valley with about 5% slope to the south. Area is densely covered with 15 to 25' Pinon Pine and Juniper trees. Logged on 7/20/74.

NOTES: Record water test and density test data, if applicable, under remarks.
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials.

*** $\frac{(\text{Lbs of rock sampled})\ 100}{(\text{Bulk specific gravity of rock})\ 62.4\ (\text{Cubic feet of hole sampled})}$
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841571

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation — Project: EMRIA — Cor. Sec. 17, T. 40 S., R. 4-1/2 W. — Hole No: TP-4

Area Designation: Alton Coal Field — Coordinates: 2050' E, 400' S of NW/ — Ground Elevation: 6570+ — Depth To Ground Water Level *: None

Method of Excavation: Back Hoe — Approximate Dimensions of Hole: 6' to 3' wide x 14' long — Dates of Excavation: 6/18/74 — Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
CL		0.0 to 2.2		Lean Clay: About 80% medium plastic fines. About 20% very fine sand. Medium toughness and dry strength. Very slow dilatancy. Checkered structure from air slaking. Several roots. Dark brown in color, and damp. Top soil, derived from weathered shale.					
CL-CH		2.2 to 3.9		Lean Clay: About 80% medium to slightly plastic fines. About 20% fine sand. High toughness, medium dry strength and very slow to no dilatancy. Several limy streaks and nodules. Material is damp, limy and rusty brown in color. Checked structure from air slaking. The base of the section contains 0.5' transitional bed of clayey gravel. The gravel is subangular limestone 1/2-inch and makes up about 80% of the bed. The fines are derived from weathered shale.					
GC		3.9 to 10.4		Dirty Gravel: About 65% poorly graded 1" subangular limestone gravel, maximum size 3". About 20% fine and coarse sand sizes. About 15% low plastic fines. Cobbles about 5% (by volume) to 10" maximum size of subangular limestone. Two bentonitic beds 0.2' thick at 5.3 and 7.4 feet. Few scattered rootlets. Material is light rusty brown in color. Walls					

REMARKS

NOTES: Record water test and density test data, if applicable, under remarks.
* Record after water has reached its natural level, give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** (Lbs of rock sampled) 100 / (Bulk specific gravity of rock) 62.4 (Cubic feet of hole sampled)
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

CONTINUED

GPO 841572

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature _____ Project _____ Hole No TP-4

Area Designation _____ Coordinates _____ Ground Elevation _____ Depth To Ground Water Level * _____

Method of Excavation _____ Approximate Dimensions of Hole _____ Dates of Excavation _____ Hole Logged By _____

CLASSIFICATION SYMBOL		DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION") GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS **				
LETTER	GRAPHIC				VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5 INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
				stand vertical for a height of 6.5 feet. Material is stratified, and dry. Classified as Pediment alluvial deposits.					

REMARKS
Test pit is located on a broad ridge with about 3% slope to the south. Area is moderately covered with 15 to 25' Junipers. Scattering of sage brush cover. Logged on 7/23/74.

NOTES Record water test and density test data, if applicable, under remarks
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** $\frac{\text{(Lbs of rock sampled)}\ 100}{\text{(Bulk specific gravity of rock)}\ 62.4\ \text{(Cubic feet of hole sampled)}}$
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

CFO 861971

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation Project: EMRIA Cor. Sec. 17, T. 40 S., R. 4-1/2 W. Hole No: TP-5
Area Designation: Alton Coal Field Coordinates: 2200' E, 1900' S of NW/ Ground Elevation: 6545+ Depth To Ground Water Level*: None
Method of Excavation: Back Hoe Approximate Dimensions of Hole: 5' to 3" wide x 15.5' long Dates of Excavation: 6/18/74 Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
Sm		0.0 to 1.7		Silty Sand: About 70% fine to very fine sand. About 30% nonplastic fines. Occasional 1/2" gravel of subangular sandstone. Several rootlets. Melts like sugar when wet. Damp, brown in color. Top-soil.					
CL		1.7 to 2.3		Lean Clay: About 60% medium to highly plastic fines. High dry strength, very slow to no dilatancy and and medium toughness. About 40% fine sand. Few limy streaks and veinlets. Materials are limy at the base. Yellow to gray brown color and damp. Sub-soil.					
Bedrock		2.3 to 3.6		Weathered Sandstone: Fine grain and limy. Checkered structure. Fragments begin to dissolve when wetted, poorly cemented. Limonite stained in places, light gray in color. Dakota Formation (kd).					
Bedrock		3.6 to 6.4		Weathered Shale: Silty to little clayey. Fissile to blockey structure. Checked from air slaking. Very weathered to more moderately weathered with depth. Gray color with limonite staining. Dakota Formation (kd).					

REMARKS

Pit is about 75 feet east of N-S ridge. Slope is about 4% east from pit. Area is moderately covered with 15-20' Juniper Trees with small sage brush cover. Logged on 7/23/74.

NOTES: Record water test and density test data, if applicable, under remarks
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials

** (Lbs of rock sampled) 100 / (Bulk specific gravity of rock) 62.4 (Cubic feet of hole sampled)
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841571

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation Project: EMRIA T. 40 S., R. 4-1/2 W. Hole No: TP-6

Area Designation: Alton Coal Field Coordinates: 1300' S of NW Cor. Sec. 17 Ground Elevation: 6590+ Depth To Ground Water Level*: None

Method of Excavation: Back Hoe Approximate Dimensions of Hole: 6' to 3' wide x 19' long Dates of Excavation: 7/9/74 Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF 3 TO 5 INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
Sc		0.0 to 2.0		Clayey Sand: About 70% fine sand and 30% slight to medium plastic fines. Trace of subrounded igneous gravel. Contains several roots throughout. Materials have a blocky structure. Damp and brown in color. Top-soil.					
Gm		2.0 to 6.8		Dirty Gravel: About 70% poorly graded 1-1/2" subangular limestone gravel, maximum size 3". About 20% fine and coarse sand sizes and 10% non-plastic fines. Cobbles 5% (by volume) of subangular limestone, maximum size 10". Few rootlets. Walls stand vertical for 7.5 feet. Materials are poorly stratified, limy and damp. Light rusty brown in color. Classified Pediment deposits.					
Bedrock		6.8 to 9.5		Shale: Clayey, blocky structure and moderately weathered. Limy chalk in top 6" with few rootlets. Damp and yellow gray in color. Top contact unconformable. Classified Tropic Formation (Kt.)					

REMARKS

Pit area is densely covered with 10 to 25' Juniper and Pinon Pine trees. Slope is about 2% to the southwest. Logged on 7/24/74.

NOTES: Record water test and density test data, if applicable, under remarks.
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials.

$$\text{Percentage by volume} = \frac{(\text{Lbs of rock sampled}) \cdot 100}{(\text{Bulk specific gravity of rock}) \cdot 62.4 \cdot (\text{Cubic feet of hole sampled})}$$

Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841971

LOG OF TEST PIT OR AUGER HOLE

FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation | Project: EMRIA | Cor. Sec. 17, T. 40 S., R. 4-1/2 W. | Hole No: TP-7

Area Designation: Alton Coal Field | Coordinates: 1600' N, 400' W of SW/ | Ground Elevation: 6570+ | Depth To Ground Water Level*: None

Method of Excavation: Back Hoe | Approximate Dimensions of Hole: 7' to 3' wide x 19' long | Dates of Excavation: 7/9/74 | Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS **				
					VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
Bedrock		0.0 to 10.0		Weathered Shale: Clayey, very weathered to 5.5 feet depth, moderately weathered below. Undiscernible bedding. Checked surfacies from air slaking. Several rootlets in top 18 inches. Tropic Formation (Kt).					

REMARKS

Pit is about 25 feet east of SE-NW trending saddle. Slope from pit is NE at 10% grade. Area moderately covered with 15-20' Juniper trees and few scrub bushes. Logged on 7/23/74.

NOTES: Record water test and density test data, if applicable, under remarks.

* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.

** Applicable only to borrow pits and to foundations which are potential sources of construction materials.

*** $\frac{\text{(Lbs of rock sampled) } 100}{\text{(Bulk specific gravity of rock) } 62.4 \text{ (Cubic feet of hole sampled)}}$

Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841571

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation Project: EMRIA Cor. Sec. 17, T. 40 S., R. 4-1/2 W Hole No: TP-8

Area Designation: Alton Coal Field Coordinates: 500' E, 150' N of SW/ Ground Elevation: 6560+ Depth To Ground Water Level *: None

Method of Excavation: Back Hoe Approximate Dimensions of Hole: 5' to 3' wide x 15' long Dates of Excavation: 7/9/74 Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION" GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 8-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 8-INCH	WEIGHT OF PLUS 8-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 8-INCH
Sm		0.0		Silty Sand: About 80% fine to very fine poorly graded sand. About 20% non-plastic fines. Structure is blocky. Basal contact is unconformable and ranges in thickness from 1.8 to 3.8 feet. Materials are light reddish-brown and damp. Several rootlets in top 18". Top-soil derived from Dakota Formation.					
Bedrock		1.8 to 9.5		Sandstone: Fine to very fine grain, sugary textured, thin bedded with iron staining along bedding planes. Contains few carbon fragments. Sandstone is poorly cemented and weathered, becoming more dense with depth. Light gray color with rust staining. At 5 foot depth is a 0.2' bed of clay with many small rootlets. Little limy in places. Dakota Formation (Kd).					

REMARKS

The sandstone described above is typically associated with coal beds in surrounding area. Pit area is densely covered with 15-25' Juniper and Pinon Pine trees with dead appearing sage brush cover. Slope is about 8% to the west.

NOTES Record water test and density test data, if applicable, under remarks
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** $\frac{(\text{Lbs of rock sampled}) 100}{(\text{Bulk specific gravity of rock}) 62.4 (\text{Cubic feet of hole sampled})}$
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841571

LOG OF TEST PIT OR AUGER HOLE

FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature Coal Strip Mining Reclamation Project EMRIA Cor. Sec. 18, T. 40 S., R 4-1/2 W. Hole No TP-9

Area Designation Alton Coal Field Coordinates 2550' E, 2200' N of SW/ Ground Elevation 6600+ Depth To Ground Water Level * None

Method of Excavation Back Hoe Approximate Dimensions of Hole 5' to 3' wide x 14' long Dates of Excavation 7/9/74 Hole Logged By Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION" GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
Sc		0.0 to 1.5		Clayey Sand: About 75% poorly graded fine sand with 25% low plastic fines. Contains several roots. Material has loose blocky structure. Damp and dark brown color. Top-soil.					
Sc		1.5 to 2.5		Clayey Sand: About 65% poorly graded fine sand with 35% low to medium plastic fines. Occasional limestone and sandstone gravels. Blocky dense structure. Contains a few roots. Becomes more gravelley and limy at basal transitional contact. Damp and reddish brown color. Sub-soil.					
Gm		2.5 to 9.0		Dirty Gravel: About 70% poorly graded 1" and 2" (skip graded) subangular limestone and sandstone gravel. About 20% fine sand with few coarse sizes and 10% slightly plastic fines. Cobbles 20% (by volume) maximum size 12" of subangular limestone, occasional boulder to 30" size. Material is limy and poorly stratified. Mottled light rusty brown color. Classified pediment deposits.					

REMARKS

Pit area is moderately to densely covered with 10 to 25' Juniper and Pinon Pine trees. Slope is about 1-1/2% to the south. Logged on 7/24/74.

NOTES Record water test and density test data, if applicable, under remarks

* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.

** Applicable only to borrow pits and to foundations which are potential sources of construction materials

"%" = (Lbs of rock sampled) 100 / (Bulk specific gravity of rock) 62.4 (Cubic feet of hole sampled)

Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation Project: EMRIA Cor. Sec. 18, T. 40 S., R. 4-1/2 W. Hole No: TP-10

Area Designation: Alton Coal Field Coordinates: 2300' E, 1900' S of NW/ Ground Elevation: 5990+ Depth To Ground Water Level *: None

Method of Excavation: Back Hoe Approximate Dimensions of Hole: 7' to 3' wide x 17' long Dates of Excavation: 7/9/74 Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
CL		0.0 to 9.0		Lean Clay: About 80% medium plastic fines with very slow dilatancy, medium dry strength and toughness. About 10% of stratified pockets of subangular limestone gravel 1" +. About 10% fine to very fine sand. Material is limy and dense with blocky structure. Several rootlets in top 12". Damp and gray in color. Classified as alluvium of reworked Tropic Shale Formation.					

REMARKS
Pit area is densely covered with knee-high sage brush and moderately covered with 15' Juniper trees. Slope is about 6% to the south. Logged on 7/24/74.

NOTES Record water test and density test data, if applicable, under remarks
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials

*** (Lbs of rock sampled) 100 / (Bulk specific gravity of rock) 62.4 (Cubic feet of hole sampled)
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation Project: EMRIA Cor. Sec. 13, T.40 S., R. 4-1/2 W. Hole No: TP-11

Area Designation: Alton Coal Field Coordinates: 1250' N, 100' W of SE/ Ground Elevation: 6555+ Depth To Ground Water Level *: None

Method of Excavation: Back Hoe Approximate Dimensions of Hole: 6' to 3' wide x 15' long Dates of Excavation: 7/9/74 Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH MATERIAL	WEIGHT OF PLUS 5-INCH SAMPLED (LBS)	PERCENTAGE BY VOLUME OF PLUS 5-INCH MATERIAL
CL		0.0 to 6.2		Sandy Lean Clay: About 70% medium plastic fines with slow dilatancy, medium dry strength and toughness. About 30% very fine to fine sand. Scattering of subangular limestone gravel 3/4"+. Material is limy, blocky in structure and checked from air slaking. Several rootlets in top 12". Damp and gray in color. Classified as alluvium of reworked Tropic Shale Formation.					
Gc		6.2 to 11.0		Dirty Gravel: About 65% subangular limestone gravel, poorly graded 1" size, maximum size 3". About 20% medium plastic fines and 15% fine sand. Material is limy, dense and stands vertical for 4.8'. Damp and mottled gray in color. Classified as alluvium deposits derived from mixtures of pediment deposits and the Tropic Formation.					

REMARKS

Pit area is densely covered with waist high sage brush and moderately covered with 15-25' Juniper trees. Slope is about 5% southeast. Logged on 7/24/74.

NOTES Record water test and density test data, if applicable, under remarks.
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Apply only to borrow pits and to foundations which are potential sources of construction materials

*** $\frac{\text{(Lbs of rock sampled) } 100}{\text{(Bulk specific gravity of rock) } 62.4 \text{ (Cubic feet of hole sampled)}}$
Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841571

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation Project: EMRIA Cor. Sec. 13, T. 40 S., R. 4-1/2 W. Hole No: TP-12

Area Designation: Alton Coal Field Coordinates: 2100' N. 1750' W of SE/ Ground Elevation: 6645± Depth To Ground Water Level*: None

Method of Excavation: Back Hoe Approximate Dimensions of Hole: 7' to 4' wide x 18' long Dates of Excavation: 7/9/74 Hole Logged By: Brandstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH
CL		0.0 to 0.8		Sandy Lean Clay: About 60% medium to low plastic fines. About 30% fine sand with some coarse sizes. About 10% scattering of subangular limestone gravel 1/2" to 3" size. Material is limy and contains several Juniper roots. Damp and dark brown color. Top-soil.					
Gm		0.8 to 10.5		Dirty Gravel: About 40% 1" size with lesser amounts of 3" size of subangular limestone gravel. About 40% of fine sand with a few coarse sizes. About 20% non to low plastic fines. Cobbles 5% (by volume) subangular limestone to 12" size. Occasional 18 to 24" boulder. Material is poorly stratified and very limy. Material will stand vertical in the pit wall for a height of 9.7 ft. but will cave in in places where more sandy. There are pockets of bentonitic materials three feet wide by 9.7 feet thick. There are several limy streaks and nodules. Material is damp to dry and mottled light yellow-brown color. Classified as pediment deposits.					

REMARKS

Pit is located on a ridge with moderate cover of 15-20 ft. Junipers. Logged on 7/25/74.

NOTES: Record water test and density test data, if applicable, under remarks.
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials

$$\%\ \text{by volume} = \frac{(\text{Lbs of rock sampled}) \times 100}{(\text{Bulk specific gravity of rock}) \times 62.4 \times (\text{Cubic feet of hole sampled})}$$

Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

GPO 841571

LOG OF TEST PIT OR AUGER HOLE
FOR BORROW AND FOUNDATION INVESTIGATIONS

Feature: Coal Strip Mining Reclamation — Project: EMRIA — Cor. Sec. 13, T. 40 S., R. 4-1/2 W. — Hole No: TP-13

Area Designation: Alton Coal Field — Coordinates: 900' E, 2000' N of SW/ — Ground Elevation: 6500+ — Depth To Ground Water Level *: None

Method of Excavation: Back Hoe — Approximate Dimensions of Hole: 5' to 3' wide x 16' long — Dates of Excavation: 7/9/74 — Hole Logged By: Branstetter

CLASSIFICATION SYMBOL LETTER	CLASSIFICATION SYMBOL GRAPHIC	DEPTH (FEET)	SIZE AND TYPE OF SAMPLE TAKEN	CLASSIFICATION AND DESCRIPTION OF MATERIAL (SEE CHART - "UNIFIED SOIL CLASSIFICATION"; GIVE GEOLOGIC AND IN-PLACE DESCRIPTION FOR FOUNDATION INVESTIGATIONS)	PERCENTAGE OF COBBLES AND BOULDERS ** VOLUME OF HOLE SAMPLED (CUBIC FEET)	WEIGHT OF 3 TO 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF 3 TO 5-INCH MATERIAL	WEIGHT OF PLUS 5-INCH SAMPLED (LBS.)	PERCENTAGE BY VOLUME OF PLUS 5-INCH MATERIAL
SM		0.0 to 2.4		Silty Sand: About 80% fine sand and 20% non to slightly plastic fines. Trace of subangular to subrounded hard gravel 1"+ size. Several rootlets. Dark brown in color. Top 6 inches moist from recent rain. Top-soil.					
GP-GW				Sandy Gravel: About 40% well graded gravel subrounded to subangular. Includes limestone, sandstone and igneous gravel, some gravels are caliche coated. About 45% fine to coarse sand and 15% slightly plastic fines. Materials are moderately limy and limonite stained in places. Light gray-brown in color and dry. There are about 25% (by volume) cobbles, subangular of limestone and sandstone, maximum size 18 inches. These materials are alluvium derived from pediment deposits.					
		10.4 TD							

REMARKS

Pit area is densely covered with sagebrush and moderately covered with 10-15' Juniper and Pinon Pine trees. Slope is 3% grade SSE. Logged on 7/16/74.

NOTES: Record water test and density test data, if applicable, under remarks.
* Record after water has reached its natural level; give date of reading adjacent to graphic symbol or in remarks.
** Applicable only to borrow pits and to foundations which are potential sources of construction materials.

$$\text{Bulk specific gravity} = \frac{\text{(Lbs of rock sampled) } 100}{\text{(Bulk specific gravity of rock) } 62.4 \text{ (Cubic feet of hole sampled)}}$$

Record bulk specific gravity in Remarks, stating how obtained (measured or estimated)

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(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Figure 5

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

Sheet 1 of 22

By: ASD | Da: 10/22/74

Location: Traverse No. 1

Treatment affecting the SSF

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 **5**	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles **7** 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 **4** 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns **4** 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits **7** 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 **6**	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 **6**	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	PRESENT SSF = 39 ÷ 100 × 100 = 39			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

Obstruction [illegible]

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(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 2 of 22

By ASD | Date 10/25/74

Location: Traverse No. 2

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 **11**	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 **14**
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 **14**
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 **11**	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 **15**
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 **12**	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **0** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL			
		PRESENT SSF = 77 ÷ 85 × 100 = 91		

Erosion Condition Classes: Stable 1–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

Instructions on reverse

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 3 of 22

By ASD | Date 10/2/74

Location: Traverse No. 3

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 **[5]**	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles **[7]** 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 **[5]**	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 **[6]**	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals gencrally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 **[5]** 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 **[3]**	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **[0]** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	PRESENT SSF = 31 ÷ 85 x 100 = 36			

Erosion Condition Class: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

Instructions on reverse

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Sheet 4 of 22

By ASD | Da 10/22/74

Location
Traverse No. 4

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 **[10]** 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 **[8]**	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 **[7]** 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 **[6]**	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans **[10]** 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 **[9]**	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **[0]** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	PRESENT SSF = 50 ÷ 85 × 100 = 59			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

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Sheet 5 of 22

By ASD | Da 10/22/74

Location Traverse No. 5

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 **[8]**	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 **[8]**	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 **[8]**	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 **[8]** 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans **[10]** 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 **[8]** 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **[0]** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL			
		PRESENT SSF = 50	÷ 85 x 100 = 59	

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

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By: ASD | Date: 10/25/74

Location: Traverse No. 6

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 **11**	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 **11**	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 **14**
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 **13** 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 **15**
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 **14**
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **0** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	PRESENT SSE = 78 ÷ 85 x 100 = 92			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

Illustrated

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By ASD | D. 10/22/74

Location: Traverse No. 7

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 **7** 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 **8**	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water **0** 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 **3**	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 **9**	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 **6**	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **0** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL	
		PRESENT SSF = 38 + 71 X 100 = 46

Erosion Condition Class: [illegible]–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

[illegible] reverse

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By ASD

Date 10/25/74

Location Traverse No. 8

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions [12] 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 [11]	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 [14]
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 [14]
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 [15]
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 [12]	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length [10] 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL	PRESENT SSF = 88 ÷ 100 x 100 = 88			

[illegible] Classes: Slight 0–20; Slight 21–40; Moderate [illegible]; Critical 61–80; Severe 81–100 [illegible]

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Location Traverse No. 9

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 **[7]** 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles **[7]** 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 **[4]** 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns **[7]** 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 **[9]**	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 **[6]**	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **[0]** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	PRESENT SSF = 40 ÷ 85 × 100 = 47			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

Instructions on reverse

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By ASD | Date 10/22/74

Location: Traverse No. 10

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 **7** 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 **8**	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 **4** 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 **5** 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 **15**
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 **9**	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 **11** 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				
		PRESENT SSF = 59 ÷ 100 × 100 = 59			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

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By: ASD | Date: 10/27/74

Location: Traverse No. 11

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 **11**	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 **10** 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 **10** 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 **11**	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 **14** 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 **11** 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 **12**	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL			
		PRESENT SSF = 79 ÷ 100 × 100 = 79		

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

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Location
Traverse No. 12

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 **5**	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles **7** 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water **0** 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 **6**	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 **6**	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 **6**	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **0** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	PRESENT SSF = 30 ÷ 71 X 100 = 42			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

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By ASD | Da 10/22/74

Location Traverse No. 13

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. [6] 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 [5] 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 [4] 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns [4] 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 [8] 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 [8] 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes [0] 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				
		PRESENT SSF = 35 ÷ 85 × 100 = 41			

Erosion Condition Classes. Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

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By ASD | Da 10/22/74

Location: Traverse No. 14

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 **[7]** 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles **[7]** 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water **[3]** 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns **[4]** 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 **[8]** 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 **[5]** 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **[0]** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL	
		PRESENT SSF = 34 ÷ 85 × 100 = 40

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

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(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 15 of 22

By ASD | Da 10/22/74

Location: Traverse No. 15

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 **10** 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 **8**	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 **7** 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 **5** 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 **9**	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 **6**	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **0** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				
		PRESENT SSF = 45 ÷ 85 x 100 = 53			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Form 7310-
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 16 of 22

By ASD | D. 10/25/74

Location: Traverse No. 16

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particlea 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions **12** 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* **12** 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away **12** 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed **12** 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. **13** 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 **12**	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 **14** 15

SITUATION	TOTAL				
		PRESENT SSF = 87 ÷ 100 × 100 = 87			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Form 7310-[illegible]
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 17 of 22

By	Date
ASD	10/22/74

Location: Traverse No. 17

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 **[7]** 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 **[8]**	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use [illegible] on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 **[10]** 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 **[6]**	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 **[8]** 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 **[5]** 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **[0]** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL	PRESENT SSF = 44 ÷ 85 X 100 = 52			

[illegible] Condition Class [illegible] -20; Slight 21-40; Moderate 41-60; Critical 61-80; Severe 81-100 (Instructions on reverse)

Form 7310–
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 18 of 22

By ASD | D. 10/25/74

Location: Traverse No. 18

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 **[10]** 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 **[11]**	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 **[11]**	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 **[9]**	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 **[9]**	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 **[11]** 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 **[8]** 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL	
		PRESENT SSF = 69 ÷ 100 × 100 = 69

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Form 7310–.
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 19 of 22

By ASD | Da. 10/25/74

Location: Traverse No. 19

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. [9] 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles [9] 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 [11]	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed [12] 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 [14] 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 [11] 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 [9]	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL	PRESENT SSF = 75 ÷ 100 X 100 = 75			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Form 7310-1
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 20 of 22

By: ASD | Date: 10/22/74

Location: Traverse No. 20

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles [4] 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 [3]	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(usually on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 [1] 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 [1] 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence [4] 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 [1] 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes [0] 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 [15]
SITUATION	TOTAL	PRESENT SSF = 29 ÷ 100 × 100 = 29			

Erosion Condition Class: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

Instructions on reverse

Form 7310–
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 21 of 22

By ASD | D. 10/25/74

Location: Traverse No. 21

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS
SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 **11**	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 **11**	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 **11**	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 **13** 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 **15**
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 **14**
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes **0** 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 6	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				
		PRESENT SSF = 75	÷85 × 100 = 88		

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Form 7310-1
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

Sheet 22 of 22

By ASD | Date 10/22/74

Location: Traverse No. 22

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT*	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 **5**	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER*	Accumulating in place 0 1 2 3	May show slight movement 4 **5** 6	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining (usually on low productive sites) 12 13 14
SURFACE ROCK*	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water **3** 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING*	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns **4** 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS*	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 **6**	Well defined, small, and few with intermittent deposits 7 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 **5** 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
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SITUATION	TOTAL	PRESENT SSF = 28 ÷ 85 x 100 = 33			

Erosion Condition Class: Stable 1–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

Instructions on reverse

7-1337 (9-60)
Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET ..... OF .....

FEATURE Alton Coal Field ..... PROJECT EMRIA ..... STATE Utah

HOLE NO. DH 101 LOCATION .....

COORDS. 383,497.25 ..... el,803,964.76 GROUND ELEV. 6654.22 ..... DIP (ANGLE FROM HORIZ.) 90°

BEGUN 7-18-74 ... FINISHED 8-7-74 ... DEPTH OF OVERBURDEN 199.7' ..... TOTAL DEPTH 235.1' ... BEARING 0

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See Notes ..... LOGGED BY D. L. Branstetter .... LOG REVIEWED BY R. T. Littleton .....

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Drilling Equipment
Longyear core drill truck mounted, hydraulic feed.

Drilling and Sampling Procedure: Core drilled with Nx size bit to total depth 235.1'. Reamed with 5 5/8" rock bit to 21.8'.

Drove Nx size casing from 21.8' to 74.2'.

Core samples taken in formation rock for testing by USGS [H] and wexes samples by BOR [X].

Drilling Fluid:
water

High Drill Fluid Loss

Depth in feet	Percent Loss
0-21.8	
21.8-34.0	70
37	100
80.3-89.3	80

Unstable or Soft Intervals: Hole caved most of total depth in the pediment gravel zone. Had to follow drill with casing.

Cemented hole from 16.1' to 21.8' and 73.2' to 78.4'.

Water Levels:

Depth in Feet	Date
70.8	8-7-74
70.9	8-8-74
176.0	9-19-74
189.1	10-16-74

Joint Index: Number denotes joints and F denotes either fractured or broken zone.

Drill Site: On west side of ridge moderately covered with 20' juniper and pinon pine trees.

Purpose of Hole: Determine depth to coal and lithology of the overburden.

Hole Completion: Set 2" standpipe to total depth. Section perforated from 209.3' to 228.8'.

TYPE AND SIZE OF HOLE

CORE RECOVERY (%)

PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs or Cm) / TO; LOSS (G.P.M.); PRESSURE (P.S.I.); LENGTH OF TEST (MIN.)

ELEVATION (FEET)

JOINT INDEX

DEPTH (FEET)

GRAPHIC LOG

SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

0.0-81.0 Pediment Gravel: Gravel, cobblea, snd bouldera, mostly subangular limestone and sandstone. These cosrse materials are in a matrix of silty sand ranging from fina to coarse grain. Gravel is commonly coated with calicbe. Color is mottled tan-gray and light gray. Bottom 0.7' is intermixed witb underlying weathered shale. Pleistocene-Alluvial deposits.

81.0-87.3 Sbale: Silty to clayey, very weathered and fissile. Can break 1" fragmente with pliers. Limy in top 5'. Air-slskes into 3/4" fragments. Dull gray color. Hairline iron stained joint at 87' witb silt costing, dips 10° to core axis. Cretaceous-Tropic Formation.

87.3-187.2 Shale: Silty to clayey, moderately weathered to fresh. Blocky to fissile structure. Can break 1/2" fragments with pliers. Modarately (18"+) bedded with bedding planes dipping 2°+ to core axis. Limy in places witb scattered limy laminae. Few bentonite lenses near base. Scattered joints. Dsrk gray color. Cretaceous-Tropic Formation.

104.1-106.3 Fractured snd jointed. Two intersecting joints are tight and dip 70° from core axis. Zone is limy.
110.3-111.4 Soft and limy.
117.2-118.2 Very fissile.
119.1-122.0 Soft and broken.

124.7-125.3 Limy with hairline joint dipping 35° from core axis.

136.2 Open joint dips 40° from core axis.

143.3-145.4 Jointed and fractured. Joints are tight and dip 35° from core axis.

145.2 Bentonite (0.9'thick), open joint at base, dips 25° from axis.
147.7 Very fissile.
149.0-150.7 Soft and limy.

154.0 Open joint dips 50° from core axis. Bedding of very fine grained sandstone.

165.8-168.4 Several septarian concretions.

165.9-166.7 Soft and limy.

172.0 Hairline to open joint, dips 25° from core axis.

175.0 Bentonite fragments along 0.2' broken zone.
179.3 and 184.1 Bentonite lens.

187.2-235.1 Interbeds Sandstone-Mudstone-Coal: Fine to very fine silty and clayey; bentonitic, carbonaceous and fossiliferous. Massive, thin to thick bedded, soft to moderately hard. Contains about 17'-thick bed of coal near top of formation.
Cretaceous-Dakota Formation

187.2-191.1 Gray mudstone witb very fine sandstone laminae.
191.1-199.7 Light gray sandatone with limy laminae. Silty and fossiliferous in bottom 2'.

199.7-218.4 Coal, several cleats along core axis in upper and lower zones. Brittle, can break 1" fragments with hard finger pressure. Dull to viterous luster. Core pieces range from 3/4" to o.6', average 0.15'. Bottom 4' has interbeds of limy sandstone.

218.4-220.4 Bentonitic fine grained sandstone.

220.4-231.0 Mudstone with lenses of sandstone, whitiab gray.

231.0-231.6 Sandstone, fine grained cross bedded, light gray

231.6-235.1 Mudstone; fine sandy and carbonaceous, light gray.

TD

EXPLANATION

CORE LOSS
CORE RECOVERY

Type of hole ..... O = Diamond, H = Hayatellite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) .. Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

7-1337 (9-69)
Bureau of Reclamation GPO 884-401

GEOLOGIC LOG OF DRILL HOLE

SHEET..... OF.....

FEATURE. Alton Coal Field PROJECT. EMRIA STATE. Utah

HOLE NO. DH 103 LOCATION GROUND ELEV. 6645.39 DIP (ANGLE FROM HORIZ.) 90°

COORDS. N. 332,869.11 E. 1,800,593.26 TOTAL

BEGUN. 8-9-74 FINISHED. 8-22-74 DEPTH OF OVERBURDEN 190.1 feet DEPTH 220.9 feet BEARING. 0

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED. See notes LOGGED BY. D. L. Branstetter LOG REVIEWED BY. R. T. Littleton

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	PERCOLATION TESTS: DEPTH (FEET) FROM (P, Cs, or Cm)	PERCOLATION TESTS: DEPTH (FEET) TO	PERCOLATION TESTS: LOSS (G.P.M.)	PERCOLATION TESTS: PRESSURE (P.S.I.)	PERCOLATION TESTS: LENGTH OF TEST (MIN.)	ELEVATION (FEET)	JOINT INDEX	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Drilling Equipment Long year core drill truck mounted; hydraulic feed. **Drilling and Sampling Procedure:** Used 5 5/8" rock bit to 38.5'. Core drilled with Nx size bit from 38.5 to total depth 220.9'. Set 4" casing to 38.5'. Core samples taken in formation rock for testing by USGS ⊨ and waxed samples by BOR ⊨. . "CSU" denotes samples sent to Colorado State University. **Drilling Fluid:** Used 2 bags of mud to 38.5' depth. Flushed system and used water to total depth. **High Drill Fluid Loss** Depth in Feet — Percent Loss 28.0-38.5 — 20 180.7-185.3 — 25 194.1-197.4 — 50 197.4-220.9 — 25 Other fluid loss intervals are less than 10 percent. **Unstable or Soft Intervals:** Used mud to prevent caving in pediment gravel zone. Zones are commonly broken and soft, about 5' to 10'. These zones range in thickness from 0.1 to 4'. See description column for depth. Coal beds caved from 190.1 to 200.2'. Three attempts at cementing interval failed with 32 gals. of 2 parts cm. to 1 part cal-seal. Over reamed zone with 3 1/2" bit for clearance. **Water Levels:** 76' depth on 8/21/74 hole at 200.2. 76' depth on 8/22/74 hole at 206.8'. **Joint Index:** Number denotes joints and F denotes either fractured or broken zone. **Drill Site:** On a gentle slope (2 percent) dipping south; area is densely covered with juniper and pinon pines 20' tall. **Purpose of Hole:** Determine depth to coal and lithology of the overburden. **Hole Completion:** Cemented in 5' of 2" pipe in hole for marker location.	WASH SAMPLES	76 100 100 100 100 83 100 100 B3 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 65 42 100 85 B9 0 98 100 58 60 94 100 TD.								1 F F F F F F 1 F F F F F F 2 2 2 F F	10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220	T.O.	CSU SAMPLE CSU SAMPLE CSU SAMPLE	**0.0-38.5 Pediment Gravel:** Gravel, cobble and boulders, mostly subangular limestone and sandstone. These coarse materials are in a matrix of silty sand ranging from fine to coarse grain. Gravel is commonly coated with caliche. Color: mottled tan-gray and light gray. Shale mixed in bottom 2 feet. Pleistocene-Alluvium **38.5-180.5 Shale:** Silty to clayey, very weathered and fissile to 39.9'. Moderately weathered to 48.3' and fresh below 48.3'. Can crush 3/4" fresh shale fragments with pliers. Blocky to fissile structure. Moderately bedded (18" ±), bedding planes dip 5° to core axis. Limy in places with scattered limy laminae. Few bentonite lenses near base. Only two joints encountered, but soft and broken in several zones. Dark gray color. Cretaceous-Tropic Formation/ 48.1 Vertical hairline joint 0.2'. 54.0-56.8 soft and broken 60.0 Irregular fracture with limy coating, fossiliferous. 70.0 Bentonite lens 74.4 Soft and broken 0.1'. 75.5 Soft and broken 0.8'. 80.8 Moderately soft and broken 0.2'. 91.3 Soft, broken and moderately limy 3.2'. 99.5 Broken with open joint dipping 45° to core axis 100.4 Bentonite lens (0.1'); light gray 108.4-112.2 Broken, moderately soft and limy 121.2-123.3 Broken and soft, very limy 132.5-134.6 Limestone; hard, gray. Grades to bentonite 134.6-136.7 Bentonite, soft, whitish-gray, occasional fossils to 140.0 151.1-153.6 Broken, moderately soft and limy 173.2 Bentonite (1.2'), soft, whitish-gray 174.5-180.4 Bentonite lens and veinlets. 180.5-220.9 Interbeds Sandstone-Mudstone-Coal: Cretaceous-Dakota Formation 180.5-190.2 Sandstone; fine grain to very fine grain near base, moderately hard, carbonaceous, dark gray 190.1-206.7 Coal; dull to vitreous, [illegible], brittle can break most 1" fragments with hard finger pressure. Core pieces range from 0.1 to 0.6' lengths. Two open cleats that parallel core axis from top to middle of coal bed. Broken and fissile from 200.2 to 203.2. Sandy bentonite nodules (3/4") below 206'. 206.7-210.6 Siltstone; whitish-gray 210.6-217.7 Shale; carbonaceous in base 0.5'. 217.7-218.5 Claystone; light gray 218.5-219.0 Sandstone; very fine grain, light gray 219.0-220.9 Claystone; broken fragments, light gray.

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole . . . . . O = Diamond, H = Hayesiliite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series) . .	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . .	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) .	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . .	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8", Nx = 3"

Comp Test

7-1337 (9-69) Bureau of Reclamation GPO 854-401

GEOLOGIC LOG OF DRILL HOLE

SHEET ...... OF ......

FEATURE Alton Coal Field PROJECT EMRIA STATE Utah

HOLE NO. DH 104 LOCATION COORDS. N. 329,583.73 E. 1,796,055.44 GROUND ELEV. 6581.31 DIP (ANGLE FROM HORIZ.) 90°

BEGUN 8-23-74 FINISHED 9-9-74 DEPTH OF OVERBURDEN 81.2 ft. TOTAL DEPTH 306.7 ft. BEARING 0

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED See remarks LOGGED BY D. L. Branstetter LOG REVIEWED BY R. T. Littleton

Column headings: NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS | TYPE AND SIZE OF HOLE | CORE RECOVERY (%) | PERCOLATION TESTS: DEPTH (FEET) FROM (F, Cs, or Cm) – TO; LOSS (G.P.M.); PRESSURE (P.S.I.); LENGTH OF TEST (MIN.) | ELEVATION (FEET) | JOINT INDEX | DEPTH (FEET) | GRAPHIC LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION

Notes on water losses and levels, casing, cementing, caving, and other drilling conditions

Drilling Equipment
Longyear core drill, truck mounted, hydraulic feed.

Drilling and Sampling Procedures
Rock bit with 5 5/8" size to 36.2' depth. Wash samples taken at 5' intervals.

Core drilled with NX size bit from 36.2' to total depth 306.7'.

Reamed with 5 5/8" rock bit to 68.5' and set 4" casing.

Reamed with 3 1/4" slug bit from 68.5' to 294.9' depth.

Core samples taken in formation rock for testing by USGS ⊢⊣ and waxed samples by BOR ⊠.

Drilling Fluid:
Water.

High Drill Fluid Loss
Losses are recorded at 10 % or less in complete hole.

Unstable or Soft Intervals: Portions of core fell from core barrel on runs 50.6, 59.0, 132.6, and 201.9. Had to drill back over core on second run to recover.

Squeezing conditions from 68.5-98.9.

Soft rock from 122.6-172.6

Caving conditions from 165 to 231.1 and 265.0 to 294.9.

Had to wash and ream hole several times to remove cuttings and caving rock below 260'.

Water Levels:

Depth in feet	Date
171.0	9-17-74
225.8	10-16-74

Joint Index
Number denotes joints and F denotes either fractured or broken zone.

Drill Site:
On a slope dipping about 5 % south, moderately covered with 20' juniper and pinon pine trees.

Purpose of Hole:
Determine depth to upper and lower coal beds and the lithology of the overburden and of rock between the coal beds.

Hole Completion:
Pulled the 68.5' of 4" casing from hole. Set 302' of 2" pipe that included 21' of perforated pipe on the bottom. The top 5' of the standpipe was cemented in hole.

Core recovery (%)

0–36.2: WASH SAMPLE

100, 92, 50, 90, 83, 100, 100, 21, 100, 100, 100, 93, 100, 77, 98, 49, 62, 100, 100, 100, 100, 100, 95, 93, 100, 86, 85, 100, 100, 72, 94, 99, 100, 100, 97, 100, 100, 100, 72, 73, 93, 100, 78

Joint index

1, 1, 1, 2, F, 1, 1, 2, 1, 1, 1

Graphic log

Classification and physical condition

0.0-59.0 Lean Clay: Low to medium plastic fines with some fine sand and scattered lenses of limestone gravel. Material is limy with local calcite crystals. Structure is blocky and massive. Firm when damp, can break 3/4" fragments with pliers when dry. Bottom 2' is very sandy. Tan to greyish-brown. Recent Alluvial deposits.

59.0-76.5 Shale: Silty to clayey, very weathered and fissile to 70'. Air slakes into 1/4" fragments upon drying. Soft and pliable when damp. Dull grayish-tan. Fresh shale below 70'. Blocky to fissile structure. Can break 1/2" fragments with pliers. Core lengths range from 0.1 to 0.4' long. Bedding planes dip 3° to core axis. Limy in places with limy laminae. Scattered fossils. Dark grey. Cretaceous-Tropic Formation.

63.5 Bentonite bed (0.8'), soft and tan.

68.0-70.0 Limy, fresh shale below 70'.

75.6-76.5 Shale; carbonaceous, fissile and black.

76.6-306.7 Interbeds Sandstone - Mudstone - Coal: Cretaceous - Dakota Formation

76.5-81.2 Sandstone; fine grain, limy and fossiliferous. Shaley near base. Dark grey.

81.2-97.8 Coal; vertical open cleats along most of core axis. Vitreous luster to dull. Crumbles into 1" fragments in top 9', lower 8' core lengths are 0.1 to 0.4' long. Silty parting 1/4" at 97.3. Can crush coal with light hammer tap.

97.8-108.8 Mudstone; silty and finely sandy. Slightly limy, bentonite in top 1'.
105 and 106 Two open joints, dip 20° from core axis. Carbonaceous along joint plane.
108.8-111.2 Sandstone; fine grain soft and friable. Limy, disseminated carbon fragments. Light gray.
111.2-117.6 Mudstone; silty, finely sandy and shaley. Carbon lenses, limy gray. Cross bedded, core lengths 0.3'.
117.6-122.5 Sandstone; fine grain hard, whitish-grey.
122.5-129.7 Mudstone; silty, clayey and limy; moderately hard, carbon trash, dark grey. Slicken sides at 127.7.
129.7-132.5 Sandstone; fine slightly limy, friable in center, greenish-gray.
132.5-149.4 Sandstone; fine slightly limy, moderately hard. Few friable lenses. Scattered carbon laminae, cross-bedded and massive. Very limy at bottom 1', greenish-grey.

149.4 Siltstone; 0.5' thick.
149.9-162.5 Sandstone; fine, moderately hard, top 1.5' is soft. Massive with few broken carbonaceous laminae. Greenish-grey.
162.5-170.0 Sandstone; medium to fine grain, moderately soft and friable. Slightly limy. Light gray.
166.9 Broken zone 0.5' thick.

170.0-173.1 Sandstone; fine grain, hard. Very limy with several fossils. Solution vugs (1/4") near base. Conglomatitic and vuggy at 172.6.
173.1-179.5 Interbeds of mudstone, siltstone, and shale. Limy and hard. Dark grey. Bottom 2' very carbonacanus.
179.5-179.8 Coal
179.8-202.5 Interbeds sandstone, siltstone, and mudstone; moderately soft, core erodes 1/8' from drill water, limy. Carbon trash and coal lenses below 197.5. Slicksides at 191.5, dips 30° from core axis.

202.5-205.7 Coal with interbeds of mudstone.
205.7-212.5 Mudstone: to very fine sandstone, limy, disseminated carbon trash, moderately hard to hard, light gray.
212.5-213.8 Siltstone; very carbonaceous, hard, black. Slickenside dips 30° from core axis.
213.8-224.4 Mudstone; slightly carbonaceous, moderately hard, air slakes into 0.2' fragments. Two slickensided joints, dip 30° from core axis, grey.
224.4-229.7 Sandstone; moderately hard, fine grain, carbonaceous laminae, whitish-gray.
229.7-234.2 Sandstone; hard, massive, whitish grey.
234.2-234.7 Shale; very carbonaceous, hard, black.
234.7-240.3 Mudstone; grades to fine sandstone, very carbonaceous in bottom 18". Moderately hard, gray.
240.2-243.0 Coal separated by 1' bed of mudstone.
243.0-251.5 Siltstone grading to fine sandstone, carbonaceous laminae, slickensides at 241.8.
251.5-260.0 Mudstone; very carbonaceous in top 1'; dark grey. Irregular slickensides at 254.6 and 259.0.
260.0-268.7 Coal; dull to vitreous luster, moderately hard. Interbeds of carbonaceous shale, black, moderately hard to hard.

268.7-276.5 Mudstone; bentonite and carbonaceous, soft to moderately hard. Greenish-gray, core lengths 0.1' to 0.7' long. Slickensides at 269.5.
276.5-287.4 Sandstone; very fine, moderately hard. Beds 0.1' to 0.7' thick and dip 5° from core axis. Few carbonaceous fragments.

287.4-306.7 Sandstone; fine, friable, poorly cemented and soft. Thickly cross-bedded 0.6' to 1.3'. Broken wavey laminae containing carbonaceous and shale fragments. Light to dark grey. Zone is possible transition into underlying Entrada Sandstone Formation.

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole .... D = Diamond, H = Haystellite, S = Shot, C = Churn
Hole sealed .... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) .. Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) .. Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series). Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) .. Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

FEATURE Alton Coal Field PROJECT EMRIA STATE Utah SHEET ... OF ... HOLE NO. DH 104

Comp
1924

7-1337 (9-69)
Bureau of Reclamation GPO 854-401

GEOLOGIC LOG OF DRILL HOLE

SHEET ..... OF .....

FEATURE: Alton Coal Field — PROJECT: EMRIA — STATE: Utah

NOLE NO.: DH-105 — LOCATION: COORDS. N. 329,975.71 ... E. 1,790,306.14 — GROUND ELEV.: 6541.12 — DIP (ANGLE FROM HORIZ.): 90°

BEGUN: 9-9-74 — FINISHED: 9-17-74 — DEPTH OF OVERBURDEN: 169.2' — TOTAL DEPTH: 205.5' — BEARING: 0

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: See Notes. — LOGGED BY: D. L. Branstetter — LOG REVIEWED BY: R. T. Littleton

NOTES ON WATER LOSSES AND LEVELS. CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS

Drilling Equipment: Longyear core drill truck mounted; hydraulic feed.

Drilling and Sampling Procedure: Rock bit with 5 5/8" size to 6.0'. Cored with NX bit from 6.0' to 16.0'. Rock bit with 3 3/4" bit from 16.0 to 65.0'. Cored with NX bit from 65.0' to 106.2'. Rock bit with 3 3/4" bit from 106.2 to 109.0. Cored with NX bit from 109.0 to total depth 205.5'.

Set 4" casing to 65.0'. Lost drill water at bottom of casing. Reamed and set casing at 75.0'.

Core samples taken in formation rock for testing by USGS [illegible] and waxed samples by BOR [illegible]. Colorado State University was sent all remaining core for testing.

High Drill Fluid Loesss:

Depth in Feet	Percent Loss
78.7-88.7	20
88.7-106.2	100

Other fluid loss intervals are 10 percent or less.

Unstable or Soft Intervals: 65.1'-75.0' soft weathered formation rock.

139.0-143.8' and 165.8-191.5, hole raveled and caved.

Water Levels:

Depth in Feet	Date
98.0	9-17-74
137.0	9-19-74
151.0	10-16-74

Joint Index: Number denotes joints and F denotes either fractured or broken zone.

Drill Site: Area is moderetely covered with sagebrush and lightly covered with 10-15' pinon pine and juniper trees. Surface slopee southeast about 2 percent grade.

Purpose of Hole: Determine depth to coal and depth of overburden.

Hole Completion: Pulled 4" casing (75 feet). Set 2" standpipe to total depth. Bottom 21' joint is perforated. Cemented plug in top 5' of hole.

TYPE AND SIZE OF HOLE — WASH SAMPLE; WASH SAMPLE

CORE RECOVERY (%) — 17; WASH SAMPLE; 57; 95; 37; 100; WASH SAMPLE; WASH SAMPLE; 100; 100; 100; 50; 100; 100; 100; 100; 100; 100; 100; 100; 100; 100; 100; T.O.

PERCOLATION TESTS

DEPTH (FEET) FROM (P, Cs, or Cm)	DEPTH (FEET) TO	LOSS (G.P.M.)	PRESSURE (P.S.I.)	LENGTH OF TEST (MIN.)

ELEVATION (FEET)

JOINT INDEX: 1; 1; 1; F

DEPTH (FEET): 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 205.5

GRAPHIC LOG: T.D.

SAMPLES FOR TESTING

CLASSIFICATION AND PHYSICAL CONDITION

0.0-65.1 Sediment Gravel: Gravel, cobbles and boulders, mostly subangular limestone and sandstone. These coarse materials are in a matrix of silty sand ranging from fine to coarse grain. Gravel is commonly coated with caliche. Color is mottled tan-gray and light gray. Pleistocene-Alluvial deposits

65.1-78.7 Shale: Silty to clayey, very weathered, blocky and fissile. Can break 1/2" fragments with fingers. Planes of fissility dip 2° to core axis. Airslakes into 0.2" piecee. Light gray to gray. Cretaceous-Tropic Formation

78.7-157.5 Shale: Silty to clayey, moderately hard. Can crush 3" fragments with pliers. Blocky to fissile locally. Moderately bedded (18"+), bedding planes dip about 3° to core axis. Limy in places with scattered limy laminae. Few bentonite lenses near base. Scattered fossile. Only one joint encountered at 111.6'. Dark gray in color. Core begins to air-slake after ½ hour exposure with hairline crecks normal to core axis. Cretaceous-Tropic Formation.

109-111 Silty, limy, massive and light gray.

111.0-113.4 Bentonite, light gray. Open joint at upper contact, dips 65° from core axis.

113.4-128.0 Silty, limy and massive. Can break ½" fragments with pliers. Air slakes upon drying into hairline cracks, ¼" apart.

140.0-152.0 Shale mostly air slakes into ¼" fragments.

143.6 Bentonite, 0.2' thick.

150.5 Bentonite 1.0' thick.

157.5-205.5 Interbeds Mudstone, Sandstone and Coal: Fine sandy, silty and clayey, bentonitic, carbonaceous and fossiliferous. Massive structure, thin to thick bedded. Moderately cemented and moderately hard. Cretaceous-Dakota Formation.

165.6-168.5 Sandstone; fine grain with carbon laminae and fossils.

168.5-169.2 Coquina in sandstone matrix.

169.2-186.6 Coal; vitreous luster, brittle, can break ¼" fragments with fingers. Few pyrite rosettes along partings. Lens (0.05' thick) at 172.4. Coal parts 0.1'to 0.3' specing normal to core axis. Two open cleats along most of core axis.

186.6-196.7 Mudstone and siltstone interbede, carbonaceous. Can crush ¼" fragments with pliers, core parts 0.2' to 0.6' normal to core axis. Greenish-gray and dark brown. Limy in places.

196.7-198.6 Shaley with slickensside at basal contact.

198.6-199.3 Sandstone, very fine to medium grain, light gray.

199.3-205.5 Mudstone; silty and [illegible] sandy. Core air slakes ¼" deep.

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole ..... D = Diamond, N = Meyerallite, S = Shot, C = Churn
Hole sealed ..... P = Packer, Cm = Cemented, Cs = Bottom of casing

Approx. size of hole (X-series)	Ex = 1-1/2",	Ax = 1-7/8",	Bx = 2-3/8",	Nx = 3"
Approx. size of core (X-series)	Ex = 7/8",	Ax = 1-1/8",	Bx = 1-5/8",	Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16",	Ax = 2-1/4",	Bx = 2-7/8",	Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2",	Ax = 1-29/32",	Bx = 2-3/8",	Nx = 3"

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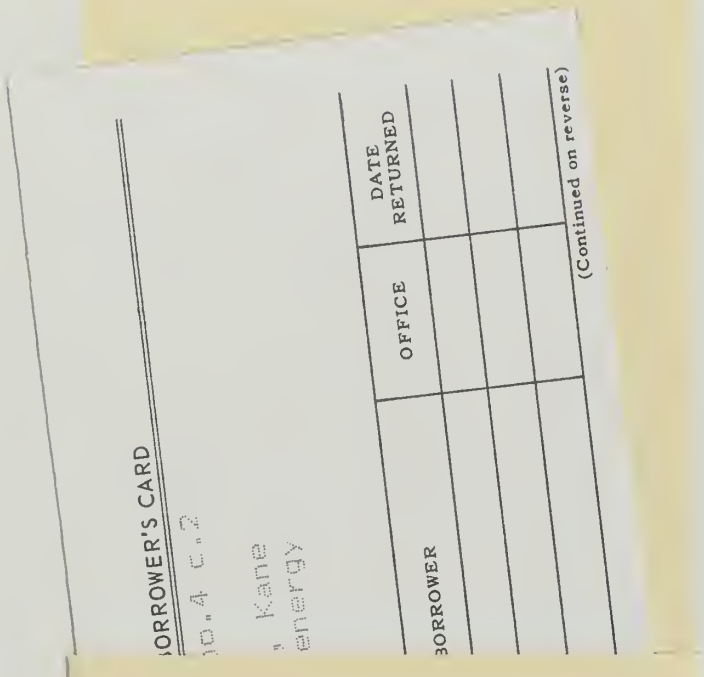

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